TAMPEREEN TEKNILLINEN YLIOPISTO
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ANALYZING SUPPLIER SELECTION CRITERIA WITH LEAN PHILOSOPHY ADOPTION: STUDY IN THE TURKISH AUTOMOTIVE INDUSTRY

Master of Science Thesis

Examiner: Professor Jarkko Rantala
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ABSTRACT

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With the increase in competition between companies in the global markets, companies try to find new ways to improve themselves and offer better value to their customers. One of the most important activities that are continuously developing in markets is supplying. Global companies look for better suppliers in order for efficient and qualified production. Therefore, they have various standards for selection of suppliers and these standards are evolving with new improvements.

Lean manufacturing originates from automotive production in order to increase the efficiency of production. Overtime it has evolved to a business philosophy and today it can be seen in many other areas beside production. One of the areas that lean is frequently seen is supply chain management. Many experts claim that in order to be lean all the activities inside a supply chain must be lean. Namely, lean companies must adopt lean supply techniques and choose their suppliers with considering lean principles.

The objective of this work is to understand the change in the requirements of customers in B2B markets with the adoption of lean philosophy. Lean mainly improves relationships, logistics and production areas; and provides efficiency in the long term with suppliers. While this study analyzes criteria change for supplier selection over years, it also shows the effect of lean diffusion on criteria selection.

Turkish automotive industry is selected in order to study criteria for supplier selection and evaluation. Thus, interviews were arranged with the managers of procurement teams in various automotive companies in Turkey. The results show that quality, delivery and relationship performance are the most important criteria for automotive manufacturers. Moreover, they require the basics of lean principles from their suppliers; even though the suppliers in the market are not considered as completely lean.

PREFACE

The topic of this master thesis originated from my studies and researches about lean production in various level of production during my master education. I decided to make a research about an industry in my home country, Turkey. Automotive industry is a good choice by means of lean production applications, and suitable for my work experiences.

I would like to thank my supervisor Professor Jarkko Rantala for his suggestions, guidance and quick responses throughout the process of topic selection and research. I also thank to the automotive managers who helped me during this research by sparing time for me and answering my questions patiently. Finally, I am thankful to my friends in Tampere for their support and help during my studies.

June 05, 2014

Munise Selin Aydin

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TERMS AND DEFINITIONS

JIT	Just in time
Kanban	Tool in a production system for lean and JIT production
Pull	Answering demand instead of creating it
OSD	Automotive manufacturers association
FDI	Foreign direct investment
OEM	Original equipment manufacturer
STA	Supplier Technical Assistance

1. INTRODUCTION

Today, the relationship with suppliers in B2B markets is more important with the increase in competition between firms. Companies establish closer and more collaborative relationships with their suppliers. Therefore, relationships are long-term and based on mutual-trust. This relationship style change has also influenced the supplier selection process. Nowadays, the value of a supplier is critical and selection of a supplier must be in detail. There are various methods and step combinations for supplier selection process. A suitable step and method are determined by the client company according to its supplier requirements.

Supplier selection process includes supplier selection criteria. Client companies determine criteria for supplier selection. This means, companies do not always prefer the one which offers the cheapest product. But they consider various features of product and supplier for procurement process. Supplier selection criteria have been changed over years. Especially, adoption of lean production influenced supplier-customer relationships and consequently supplier selection criteria. Today, lean principles are also considered while selecting suppliers.

Automotive industry is one of the largest industries in the world and it also has the one of the most complex supply chains. An automotive OEM has so many supplied products and suppliers; because an automotive consists of so many different products from rubber to textile. This makes supplier selection in automotive industry more crucial than many other industries. As it is widely known, lean production is common in the automotive industry. Therefore, the effect of lean production in supplier selection criteria of automotive industry becomes interesting.

The aim of this work is to understand criteria selection of industries and the effect of lean production on criteria selection. Therefore, the following areas will be discussed in this paper. First, factors that influence the criteria selection, criteria selection based on industries and countries. Second, lean production requirements for suppliers and supplier selection with lean principles.

Moreover, a study has been done in Turkish automotive industry about supplier selection processes. The procurement managers of reputational Turkish automotive brands were interviewed and common trends in supplier selection process were determined. Also, a questionnaire about supplier selection criteria was filled by managers to determine the important criteria for Turkish automotive OEMs. Finally, effect of lean production on Turkish automotive suppliers were tried to be understood with related questions.

1.1 Research questions and the objective of the research

The objective of this paper is to increase the understanding on which factors have influence on supplier selection process of organizations and how lean ideas have improved and changed the decision of suppliers. Automotive industry is selected as a research area and the following questions are formulated.

Comprehensive questions for this work:

- Is it possible to determine the common significant criteria for supplier selection?
- Which factors have an influence on supplier selection criteria of organizations?

Questions related to lean production:

- Does lean philosophy influence supply chains? In what way?
- How lean philosophy influences the supplier selection criteria of organizations?

Final research questions about automotive industry:

- What are the important criteria for selection of suppliers in Turkish automotive industry?
- What is the effect of lean philosophy while selecting suppliers in Turkish automotive industry?

1.2 Research methodology and research process

Research is gaining new knowledge and finding solutions to problems by a methodical and systematic approach (Kumar 2008; Amaratunga et al. 2002). Research methodology shows the approach and technique of the research and describes the way research is conducted (Kumar 2008).

There are various research approaches for categorizing type of a research and each research approach has a different strategy. First of all, a research can be classified as quantitative or qualitative. Qualitative research is described by observations to express the real and natural situations, while quantitative research concentrates on numerical data and uses statistical methods (Amaratunga et al. 2002). Some common quantitative methods are experiments, questionnaires and historical data. Experiments are scientific methods to demonstrate relationships between variables. Surveys ask questions to various people to collect information. Historical data are useful looking for patterns. On the other hand, case studies and action researches are classified as

qualitative research methods. Case studies are observations in real world in order to understand the phenomenon in its natural environment. Action researches apply the idea into practice and researcher can change the results by his actions. (Moody 2002) In this paper both quantitative and qualitative approaches were used.

Moreover, researches can be classified as theoretical or empirical. Theoretical research uses theoretic constructs in order to find the answers. Empirical study collects data and analyzes it in order to report and find out the results. Empirical research also includes reviewing of existing theories. Then it gathers the information and obtains results. (Moody 2002)

Finally a research approach can be inductive or deductive. Inductive approach generalizes the theory from the existing data. It is also called bottom-up research. However, deductive approach begins with a hypothesis then finalizes with a narrow and specific theories. Deductive approach is called top-down research. (Heit & Rotello 2010)

It is important to choose the right data generating methods to achieve the research objectives. According to Gummerson (1993), there are five data generating methods for management research. These are;

- Using existing material
- Questionnaires and surveys
- Interviews
- Observation
- Action research (Gummesson 1993)

First method is using existing materials that has been published before. Academic literatures are used for this type of research in order to build a scientific framework of the subject. This method usually focuses on the study of indirect materials, because otherwise researcher is limited with few mature theories. Some subject related academic literatures are researched even though they do not include the exactly same issue in the case. Existing materials provide theoretical support to the claimed ideas. Secondly, for questionnaires and surveys, the researcher prepares questions and distributes them to target group. The selection of the target group is important for an accurate analysis. Surveys and questionnaires can be distributed by mail, telephone or online. Thirdly, interviews are face to face discussions, usually longer than surveys and questionnaires. Interviews can be done either systematically or free of structure. Usually, the capability of the interviewer influence the quality of the interview (Ott & Longnecker 2010). Fourthly, observation is watching and analyzing a process and it requires self-participation. Usually, the result of the observation is highly subjective; therefore, reliability of the research can be disputable. Finally, action research is self-participation of the researcher in the business. Therefore, researcher can shape or change the processes and the result highly depends on the researcher's personal experience.

For this study, both qualitative and quantitative researches are conducted. Qualitative data was collected by interviews; also questionnaires were done in order to collect quantitative data. Both quantitative and qualitative data are used for the final results. For qualitative research, case study research is done by observing real world to understand the phenomena. Moreover, this study is empirical because it first collects the existing theories and literature and uses gathered data to answer the questions and analyze them. Finally, this research approach is deductive because the study was narrowed from the general supplier selection theories to specific area theories in an industry.

When data gathering methods are considered, two different methods are used for this thesis. These are using existing material and interviews. The author first researched the literature from past to present, picked the related information and used it in the analysis. Old sources are used to demonstrate the change over time and recent publications provide current trends in the business life. Many publications are read during this research which includes books, journal articles, research papers and reports. However, the research is limited with the accessibility of the publications. With combining information in the existing literature, the author constructed a way of thinking and came to a conclusion. In the second and final part of the thesis, the author had an interview with managers of a selected industry. Author aims to understand the concept in real business and to show the results from a special industry in a country. Moreover, the information given in the literature is compared with the real values from the industry.

1.3 Structure of the thesis

The structure of this thesis consists of 8 chapters including the introduction.

Chapter 2. Supplier Selection

This chapter first introduces supplier-customer relationship and its different relationship types with their advantages and drawbacks. Then, supplier selection process is described according to required relationship type. Steps of the selection process that is applied in various industries are listed. This chapter finishes with a short introduction of ‘supplier selection criteria’ which is an important step of selection process.

Chapter 3. Fundamentals of Supplier Selection Criteria

The aim of this chapter is to give a deep understanding of criteria that are used today for supplier selection. To do this, the evolution of criteria is described from past to expected future. Also, criteria selection for different industries, countries and company types are mentioned in order to figure out how to choose proper criteria for supplier selection.

Chapter 4. Lean Manufacturing

This chapter explains lean manufacturing starting from its origins to today usage in industries. Change of lean from manufacturing technique to a philosophy is expressed with lean characteristics and techniques. Changes in companies (so industries) are described with the adoption of lean techniques. Final part of this chapter focuses on effects of lean ideas on suppliers and supply chains by means of relationship style, production and logistic performance.

Chapter 5. Automotive Industry

Since the study conducted in automotive industry, this chapter overviews the industry, its characteristics and characteristics of suppliers and supplying activities. Information related to Turkish automotive industry is also provided in order to understand the place of Turkey among all automotive industry in the world.

Chapter 6. Findings from Automotive Industry

This chapter contains the study results from Turkish automotive industry and it is divided into two sections. In the first section, the results of supplier selection criteria in the industry are analyzed. Second section illustrates the effect of lean manufacturing on supplier selection in Turkish automotive industry. Both results are compared with the researches from the previous chapters.

Chapter 7. Discussions

Final chapter exposes the conclusions that are achieved through this study. This part also includes the limitations of this research with its reasons and research possibilities in this subject that could be done in the future.

2. SUPPLIER SELECTION

2.1 Supplier-customer relationship

A relationship between a client and a supplier is built in order to satisfy each other's needs. Each party in a relationship has some responsibilities which are stated in a contract. Contract is an agreement that explains the definition of relationship. (Booth 2010) Relationship with suppliers affects the overall performance of a company; therefore, type and level of relationship are critical factors for customers. A relationship must create value for both parties by achieving best possible financial performance (Lambert & Schwieterman 2012). Moreover, because of switching costs and switching time, co-operation is usually more profitable in a relationship with suppliers (Masella et al. 2000).

The authors have been using various methods to categorize relationship types between clients and suppliers. The most popular categorization types for relationships are strength, closeness and physical proximity (Kannan & Tan 2006). Booth (2010) describes different relationships by flow of information between each business. He explains two types of relationship which are bow-tie relationship and diamond relationship. If there is a restricted access to information and limited number of contacts between customer and supplier, the relationship is called bow-tie relationship. On the other hand, if there is an informed access and many contacts between them, it is called diamond relationship. (Booth 2010) Bow tie and diamond relationship can be seen in Figure 1 and Figure 2 respectively.

Booth (2010) also describes the supplier relationships by means of their strategy type. He offers three strategy types, these are called deliver, align and collaborate. First, in the deliver type, relationship is limited to delivery and payment. Second, align relationship includes some transparency and alignment. Finally, in a collaborate type of relationship, both parties benefit from the relationship. This is achieved by a closer relationship and sharing critical goods and services. (Booth 2010) Relationships have some traits; most common traits are collaboration, commitment, communication, trust, coordination, dependence, flexibility (Kannan & Tan 2006). Traits can also clue about type of the relationship.

Figure 1. Bow tie relationship (Palmatier 2011)

Figure 2. Diamond relationship (Palmatier 2011)

According to Choy et al. (2004), there have been several changes in the business environment like increase in international competition, technological improvements, improvements in customer knowledge and needs. These changes create a challenging environment for companies. Companies have to find better ways to increase their total performance of businesses or even to stay in the market. (Choy et al. 2004) Today, relationships between customers and suppliers are closer in order to have a quality relationship and to improve total profit in the long term (Deshmukh & Chaudhari 2011). Choy et al. (2004) call this type of relationship as inter-enterprise relationship. This collaborative and closer relationship provides improved business processes in the whole supply chain.

Moreover, today relationships with suppliers heavily depend on sharing information and having many closer contacts. Customer companies also share overall success or failure with their suppliers. This integration helps to improve overall

performance of organizations. Companies that have key suppliers with long-term collaboration are more able to reduce their costs, have rapid product cycle, optimize inventory level, innovate new products, diminish risk and uncertainty and create better value for their customers (Lambert & Schwieterman 2012; Choy et al. 2004). Another advantage of this relationship is that suppliers become more motivated with secure long-term collaboration, positioning in a reliable market and influencing customer quality positively (Kannan & Tan 2006). While supplier and customer benefit from a good relationship, entry barriers for competitors increase with long-term strong relationships. Lean production effects relationship style between client and supplier organizations. It is known that the evolution of supplier relationships has been influenced a lot from lean philosophy. The effect of lean on supplier relationship will be discussed in detail in lean production chapter.

According to Park et al. (2010), supplier relationship includes studies in four areas; these are purchasing strategy, supplier selection, collaboration and supplier development (Park et al. 2010). This paper aims to focus on supplier selection. The following topics give an insight into supplier selection processes.

2.2 Supplier selection process

2.2.1 Description of supplier selection process

Today, competition among firms is fiercer than past; mainly because of globalization. This competitive business environment force companies to enhance their quality and services while reducing costs. Therefore, companies take into account every factor that they can reduce costs and improve productivity. One way to achieve this is improving supply chain performance. Since procurement is one of the most critical activities in supply chain management, supplier selection is important for organizations to improve their performance. Doing business with appropriate suppliers provides many advantages to firms in the long run. Under this topic, the objective of supplier selection and its processes will be discussed.

Supplier selection is a critical decision in supply chain activities; because, suppliers play an important role for performance of a company. Final product quality and total productivity highly depend on supplied products and services. (Ravindran & Wadhwa 2009; González et al. 2004) Therefore, it can be said that all suppliers in a chain contribute to the performance of the final product that is sold to consumers. When a supplier gets into an already established supply chain, it affects all the companies on a supply chain. Therefore companies put so much effort into supplier selection process to determine the best possible supplier. Degree of effort that is spent for selection process increases with the importance of goods or service that will be purchased (Monczka et al. 2009).

Supplier selection process must aim continuous improvement. New suppliers can provide improvement by reducing purchasing risks and maximizing overall value to customer. (González et al. 2004; Monczka et al. 2009) According to Monczka et al. (2009), effective selection of suppliers provides firms to improve profitability and enhance customer satisfaction from four ways: (1) competitive pricing, (2) delivery service, (3) product quality and (4) product variety (Tracey & Tan 2001).

A company may need a new supplier because of several reasons like new product development, insufficient supplier, end of a supplier contract, buying new machinery or expanding to new markets (Monczka et al. 2009). In any case, the company must follow some procedures before decide on a supplier. The following topic will explain these procedures.

2.2.2 Steps of supplier selection process

The steps of supplier selection process are explained in many publications. Every author builds their own diagram for supplier selection steps. The Figure 3 represents the summary of the steps that is expressed by various authors.

The figure shows the basic steps of supplier selection process. The order of steps may change or additional steps may be added according to circumstance. First step is identifying the need for a new supplier. New supplier may be needed because current suppliers are not efficient enough or new part/product is necessary. Purchasing managers are responsible for this step; but for procurement of new part/product engineers provide specifications of required goods or services to buy (Monczka et al. 2009; Ravindran & Wadhwa 2009). After managers agree on the need they move on to the next step.

Secondly, sourcing strategy must be determined. The strategy includes number of suppliers, type of relationships and type of supplier (Masella et al. 2000; Monczka et al. 2009). Customer decides either single sourcing or multi-sourcing for procurement. There are various reasons of working with multiple suppliers rather than only one supplier. Mainly, multi-sourcing minimizes the risks because some items can be purchased from different suppliers (Ravindran & Wadhwa 2009). Type of relationship has several meanings like long-term or short term relationship or integration between supplier and customer (Masella et al. 2000; Monczka et al. 2009). Long-term and close relationships require more effort and investment; however, they have many benefits to both customer and supplier in the long run (Masella et al. 2000). Type of supplier can be change depend on procurement and company. For example, some companies may consider only domestic suppliers in some situations (Monczka et al. 2009).

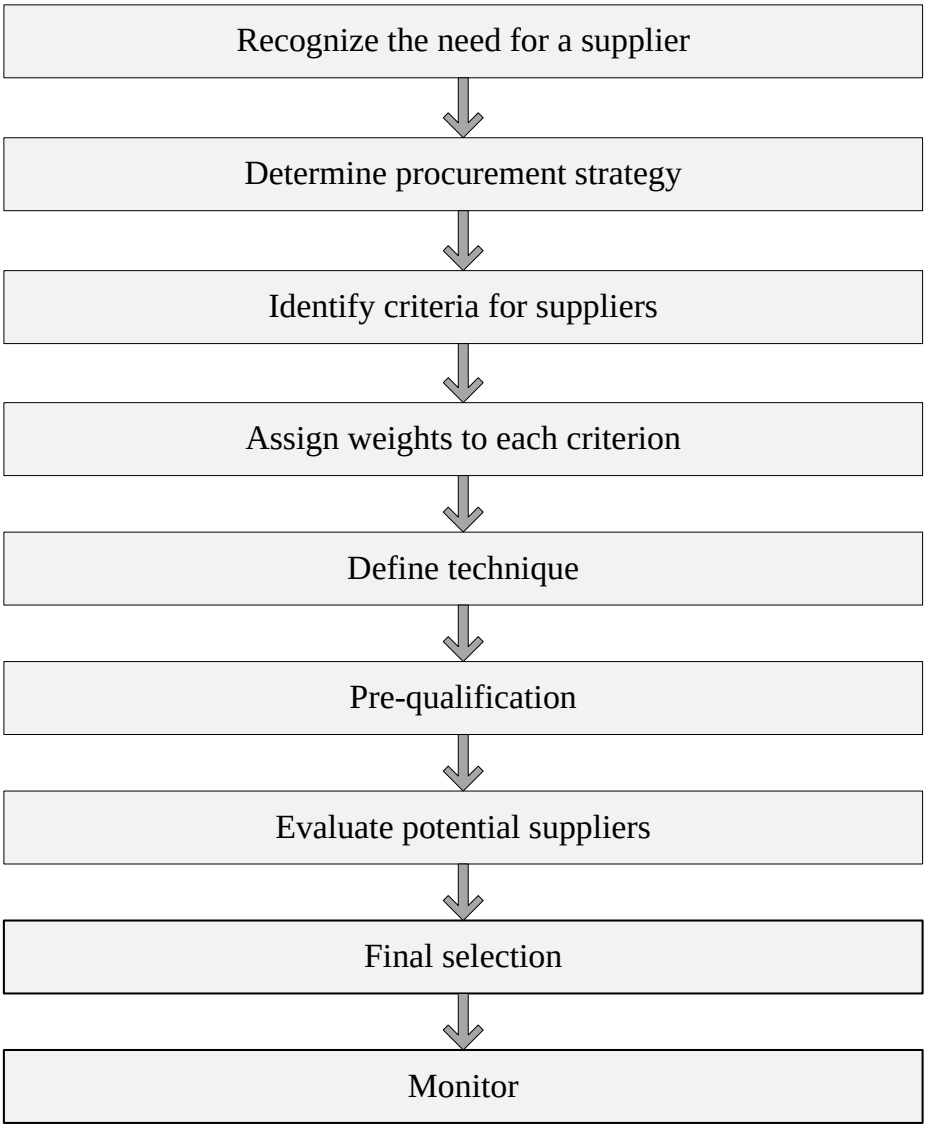


Figure 3. Steps of Supplier Selection Process (Monczka et al. 2009; Ravindran & Wadhwa 2009; Masella et al. 2000; Sonmez 2006; Lee et al. 2001; Ghodsypour & O'Brien 1998)

Thirdly, important criteria for customer must be determined in order to evaluate suppliers. The aim of this step is to understand which factors are critical for customer and selecting suppliers considering these critical factors. While selecting suppliers, more than one factor must be considered; therefore, supplier selection problem is called as multi-criteria problem (Deshmukh & Chaudhari 2011). Moreover, these criteria can be both quantitative and qualitative. According to Ravindran and Wadhwa (2009), there are two types of selection criteria. First one is criteria that are related to suppliers like potential risks, capacity, and location of the supplier. Second type includes the criteria that are directly related to required product or service like its type or life-cycle. (Ravindran & Wadhwa 2009) Criteria list of a customer must be combination of these types. Effective selection of criteria helps firms to determine suppliers which can

provide competitive pricing, better delivery service, better product quality and variety (Tracey & Tan 2001). These benefits can be obtained by well-determined factors, or in other words multi-criteria (Park et al. 2010). Here, criteria concept is introduced, a detail analysis of supplier selection criteria will be provided in the next chapters.

Every criterion has different level of importance for customer. A good way to understand the value of each criterion is assigning weights to each of them. Therefore, after defining criteria, fourth step is determining weights. Then, suppliers can be evaluated and weights for each supplier can be calculated (Lee et al. 2001). Identifying weights also gives information to firm about which values are more important for them (Monczka et al. 2009).

Fifthly, technique for evaluating criteria and selecting suppliers are determined by the customer company. In the literature, various methods are offered and discussed. In this paper, only the most common techniques will be mentioned since it is not the objective of this paper. The following table lists the most popular methods for supplier selection process.

Table 1. Common methods for supplier selection (Ravindran & Wadhwa 2009; Masella et al. 2000; Ghodsypour & O'Brien 1998; de Boer et al. 2001; Park et al. 2010)

Method name	**Features**
Linear Weight Method	Most common method Depends on mostly human judgments
Cost Ratio Method	Relatively complicated method Requires financial information
Analytical Hierarchy Process (AHP)	Widely used method Pairwise comparison Flexible Accurate Includes quantitative and qualitative alternatives
Total Cost of Ownership (TCO)	Understands true cost of a purchase Determine value of each function Selects the lowest cost
Mathematical Programing Methods	A formulation method Maximizes or minimizes values
Artificial Intelligence based Method	Neutral networks Formulation is not required Able to cope with complexity and uncertainty

As it can be seen from Table 1, various methods have different features; therefore, client companies can select the one which is most suitable for their supplier selection system.

The sixth step of supplier selection process is pre-qualification. Some authors put this step before criteria determination, while others put it after supplier selection techniques. Regardless of its place, it aims reducing number of suppliers with the help of some basic criteria (Monczka et al. 2009). Therefore, after pre-qualification step, buyer can focus on few suppliers to evaluate them and the total effort can be reduced (Ravindran & Wadhwa 2009).

Seventhly, the potential suppliers are evaluated by customer before making the final decision. Before this step suppliers must be eliminated, therefore, this process is done for few suppliers (Ravindran & Wadhwa 2009). According to Monczka et al. (2009), evaluation is done in order to obtain more information about suppliers. Information can be gathered by supplier visits and asking for information from external sources about suppliers. (Monczka et al. 2009)

Finally, the most appropriate supplier is selected for procurement, and then relationship is established. However, supplier evaluation never ends completely. Supplier is monitored and controlled throughout life of relationship. Companies evaluate their suppliers regularly and provide feedback in order to rectify shortcomings and improve their relationship. (Ravindran & Wadhwa 2009; Monczka et al. 2009; Sonmez 2006)

2.2.3 Understanding supplier selection process

Supplier selection process is usually a complex activity because of several factors (Park et al. 2010; Davidrajuh 2003). Firstly, more than one criterion is considered in selection process. While a potential supplier perform better about a criterion, other potential suppliers may be better in other criteria. Namely, each supplier has different specialty; and duty of a customer is finding the optimum one in some way. (Park et al. 2010) In order to find the optimum one in multi-criteria selection, companies apply different methods. Secondly, supplier selection decisions are given by multiple-person. In some situations, people from various authority levels play role on decision activity. This makes decision process longer and more complex. Thirdly, decision process depends on the product that will be purchased. In other words, same decision process cannot be applied on every supplied product or service. For example, procurement procedures changes whether supplied products are capital equipment or MRO (maintenance, repair, operating). Finally, type of relationship also changes and determines the decision process. Companies follow different processes for short-term and long-term suppliers; or collaborative and non-collaborative suppliers. Differences and applying various methods also make decision process difficult for customer companies. (Davidrajuh 2003)

The process of supplier selection was described with its meaning, steps and methods. The aim of discussing supplier selection process is to introduce and understand supplier criteria concept. Therefore, the next topic will be about supplier selection criteria.

2.3 Supplier selection criteria

In the previous topic, it was mentioned that the objective of supplier selection process is to find optimal supplier for organization. However, an optimal supplier is not necessarily the one who offers cheapest product or superior delivery service. Besides cost and delivery service, many other factors must be considered to determine the optimal supplier. There have been proposed hundreds of criteria in the literature for supplier selection process (Ho et al. 2010). In this topic, supplier selection criteria and its utilization will be introduced.

In supplier selection process companies evaluate and eliminate potential suppliers. Kahraman et al. (2003) expressed that criteria make elimination process possible by helping determination of whether a supplier conforms with strategy of an organization or not. Criteria are considered as a measurement system that can measure suppliers in terms of their financial strength, management approach, capability, technical ability, resources and quality systems. (Kahraman et al. 2003) Supplier selection process must include multiple-criteria and those criteria must be deep enough that include all the aspects of supplier like management, employee, technology and finance (Tracey & Tan 2001; Ng 2008). All in all, with the help of criteria organizations can evaluate suppliers in terms of many different aspects.

In the literature there are several ways offered to categorize criteria in supplier selection process. One of them, proposed by Masella et al. (2000), classifies categories by their place on the supply chain as output variables, input variables and state variables. First, input variables are leverages that a supplier has like investments and environmental factors. Second, state variables are resources of a supplier that are used in production process like manufacturing resources and technological resources. Third, output variables show a supplier's final performance like manufacturing performance and technological performance. Customers define criteria by considering these three variables and final list of criteria must cover all three variables for a good examination. (Masella et al. 2000)

Another common approach in the literature is selecting suppliers with considering three aspects. These are (1) Level of buyer-supplier integration, (2) competitive situation of the company and (3) corporate strategies. Table 2 shows the example criteria for different level of integration. In the table, there are five levels. Level 1 represents a relationship without any integration which includes only purchasing and delivering activities. Level 5 represents close and collaborative business partnership. For level 1, only price and quality criteria are considered while selecting suppliers. When integration level steps up, new criteria are added to list. Therefore, relationships with high integration require more analysis and more detailed selection.

Table 2. Criteria with different level of integration (Ghodsypour & O'Brien 1998)

Level of Integration	Definition	Criteria
Level 1	no integration	price, quality
Level 2	logistic integration	price, quality + reliability, flexibility, lots, lead time
Level 3	operational integration	price, quality, reliability, flexibility, lots, lead time + process capability, high flexibility, JIT
Level 4	integration in process and products	price, quality, reliability, flexibility, lots, lead time, process capability, high flexibility, JIT + human resource, design involvement, management ability, culture
Level 5	business partnership	price, quality, reliability, flexibility, lots, lead time, process capability, high flexibility, JIT, human resource, design involvement, management ability, culture + best supplier in human resource and technology

Sim et al. (2010) classifies criteria in six main categories these are (1) price, (2) delivery, (3) quality, (4) services, (5) relationship, (6) management and organizational status. Then every other sub categories can be considered under these main titles. (Sim et al. 2010) Different authors have determined various main categories to categorize criteria and some of them will be mentioned in the next topic.

After determining list of criteria, it is usually observed that criteria are conflicting between potential suppliers. While some suppliers are very good in a criterion, they can be worse in other selected criterion. This is the hardest challenge about supplier selection. (Ravindran & Wadhwa 2009) Braglia and Petroni describes this situation as customer must tradeoff between tangible and intangible factors (Braglia & Petroni 2000). This process is also called criteria optimization for supplier selection in the literature (Ravindran & Wadhwa 2009).

Because of different factors in the business world like globalization and increase in competition, importance of each criterion has been changing. However, some criteria are always considered as critical criteria. These criteria are mainly price (cost), quality and delivery (Monczka et al. 2009). The next chapter will deeply analyze supplier selection criteria with history, evolution and future.

3. FUNDEMENTALS OF SUPPLIER SELECTION CRITERIA

3.1 History of supplier selection criteria

Supplier selection criteria have been being analyzed and discussed in the literature since 1960s. First work about supplier selection was published in 1966 (Nakashima & Gupta 2013). Dickson (1966), published an article which name is "An analysis of vendor selection systems and decisions" in 1966 (Dickson 1966). In order to identify most important criteria in supplier selection, he sent a questionnaire to 273 purchasing agents and managers from the membership of the National Association of purchasing managers (Benyoucef et al. 2003). Managers chose their criteria for supplier selection and based on their choices Dickson found 23 important criteria based on the questionnaire result (Dickson 1966). Table 3 shows these 23 criteria of Dickson study with their importance rank.

Table 3. Dickson's supplier selection criteria (Dickson 1966)

Number	Factor	Mean	Relative Importance
1	Quality	3.508	Extreme importance
2	Delivery	3.417	
3	Performance History	2.998	
4	Warranties & Claim Policies	2.849	
5	Production Facilities and Capability	2.775	Considerable importance
6	Price	2.758	
7	Technical Capability	2.545	
8	Financial Position	2.514	
9	Procedural Compliance	2.488	
10	Communication System	2.426	
11	Reputation and Position in Industry	2.412	
12	Desire for Business	2.256	
13	Management and Organization	2.216	
14	Operating Controls	2.211	
15	Repair Service	2.187	Average importance
16	Attitude	2.120	
17	Impression	2.054	
18	Packaging Ability	2.009	

19	Labor Relations Record	2.003	
20	Geographical Location	1.872	
21	Amount of Past Business	1.597	
22	Training Aids	1.537	
23	Reciprocal Arrangements	0.610	Slight importance

According to Table 3, the most important criteria were quality, delivery and performance history respectively. Unexpectedly, price was not in the top three in managers' choices.

Dickson (1966) also found out that important parameters can be changed in different industries. Table 4 shows the selected most crucial criteria in four different case industries. According to the table top five criteria are more or less same in different industries; but their importance order can switch depend on the industry. (Dickson 1966)

Table 4. Most important factors by situation (Dickson 1966)

Importance Rank	**Case A: Paint**	**Case B: Desks**
1	Quality	Price
2	Warranties	Quality
3	Delivery	Delivery
4	Performance History	Warranties
5	Price	Performance History
Importance Rank	**Case C: Computers**	**Case D: Art Work**
1	Quality	Delivery
2	Technical Capability	Production Capacity
3	Delivery	Quality
4	Production Capacity	Performance History
5	Performance History	Communication System

Dickson's study confirmed that price is not always the determinative factor for supplier selection. Most significant criteria were quality, on time delivery, performance history and warranty policy at that time. Technical capability and production capability were also as important as price of a product. (Dickson 1966)

In 1980, Shipley conducted a study about criteria of supplier selection and he introduced four set of criteria. These are (1) expected product, (2) augmented product, (3) information availability and (4) efficiency. Expected product is the most critical criteria that includes all the characteristics of a product that customer purchase.

Augmented product covers all extra benefits of the product like quality packaging, prompt sales quotation, and product range and credit terms. Information availability is also considered as an important factor since it diminishes the degree of risk and uncertainty. Finally, efficiency means the efficient work of supplier like its productivity and profitability. Shipley also stated that price is not the most significant factor in purchasing operations. (Shipley 1980)

After Dickson study on supplier selection criteria, Weber et al. (1991) conducted a detail research with the articles that were written after 1966. He reviewed 74 articles and categorized them based on Dickson's selected 23 criteria. He found out that price, delivery and quality and services are critical and they were mentioned a lot in the articles he reviewed. (Weber et al. 1991) Weber study is the widest study after Dickson's questionnaire; however, it should be bear in mind that their research methods were different.

Benyoucef at al. (2003) discuss the Weber's research and believe that the evolution of industrial environment changed the importance of Dickson's criteria list. Criteria like communication system, desire of business, management of organization are significant in industrial environment; even though they are not on the top positions in the list. (Benyoucef et al. 2003) Weber et al. (1991) states that JIT manufacturing emerged after the Dickson's study and geographical location is highly significant in JIT environment (Weber et al. 1991).

The results of the Weber's study shows that most important criteria were price (90%), quality (86%) and delivery (76%). Production facility and production capacity were the following criteria in the list. (Weber et al. 1991) According to Deshmukh and Chaudhari (2011), during Weber et al. (1991) research, supplier's financial information and stability were not so much important; because there were not close relationships between supplier and customer. Also, communication systems were also not significant since information sharing were not considered. Global sourcing was not popular; and geographical location was extremely important for customers while selecting their suppliers since global logistics had not been improved at that time. (Deshmukh & Chaudhari 2011)

After Weber's research in 1991, globalization changed the supplier selection criteria. Some factors influenced criteria like culture, communication, relationship, exchange rates and tariffs. Also, before 1990's mostly quantitative criteria were dominant; but criteria became more qualitative after 1990's. (Kar & Pani 2014) These changes led to dominance of quality and service over price and emerge of JIT principles (Ravindran & Wadhwa 2009).

This topic tried to give insight into history and development of supplier selection criteria; next topic will explain the important and proper criteria in today's world for supplier selection.

3.2 How to choose proper supplier selection criteria

3.2.1 Main criteria and sub-criteria concept

As it is known from the previous chapter, the most popular and mentioned criteria for supplier selection are net price, quality and delivery (Deshmukh & Chaudhari 2011; Park et al. 2010). There are so many sub-criteria that are considered under price, quality and delivery concept. Table 5 shows the popular sub-criteria of these three popular main criteria.

Table 5. Popular sub-criteria of price, quality and delivery (Deshmukh & Chaudhari 2011; Sim et al. 2010)

Criteria	Price	Quality	Delivery
Sub-criteria	• Low price • Free distribution/logistic costs • Free after sales service • Ordering price • Discount for bulk order • Discount for early payment	• Meeting minimum standard & requirement • Long durability • ISO certified • Low rejection/return date • Provide sample before first ordering	• On time delivery • Short delivery lead time • Reliable delivery method • Good packaging • Product received in good condition • No error in product type & quantity • Delivery capacity • JIT capability

Price, quality and delivery are considered as traditional criteria since they were the only important parameters for supplier selection in the past (Kannan & Tan 2006). However, today companies have to evaluate overall capability of a supplier. Overall capability includes parameters like production capability, technological capability and reputation. (Wong et al. 2012)

Apart from price, quality and delivery, purchasing managers and authors that research about supplier selection criteria formed their own major criteria. After categorization of main criteria, they determine the sub-criteria for each main criterion (Benyoucef et al. 2003). Therefore, classification of criteria becomes easier and more understandable. Calvi et al. (2010) proposes a hierarchy of criteria for ranking suppliers. It includes three major classifications; and these are (1) “Direct benefit potential through buyer involvement” which includes cost reduction, quality improvement and delivery improvement; (2) “Success factors” includes supplier capability, commitment and relationship quality; (3) “Strategic importance of supplier” includes supplier

competitiveness and risk assessment. (Calvi et al. 2010) Sim et al. (2010) used six major criteria in the research about supplier selection criteria in Malaysia. Three of the major criteria were the most popular ones (cost, quality and delivery) and the rest three were services, supplier relationship, and management and organization. (Sim et al. 2010)

3.2.2 Criteria comparison and popularity

In the previous topic, popular and significant criteria were discussed. Today's important criteria were also examined by various authors. Deshmuhk and Chaudhari (2011) repeated Weber study which was done in 1991. They reviewed articles until 2011 and categorized them based on Dickson's 23 criteria. Dickson's 23 criteria were compared with Weber's study and today's popularity was investigated. Table 6 shows the comparison of Dickson's, Weber et al.'s and Deshmuhk & Chaudhari's study. In the table, number of articles that each criterion presents and their percentage can be found.

Table 6. Change of criteria importance over years (Dickson 1966; Weber et al. 1991; Deshmukh & Chaudhari 2011)

Criteria	**Dickson (1966)**	**Weber et al. (1991)**		**Deshmuhk & Chaudhari (2011)**		
	Rank	**No.**	**%**	**No**	**%**	**Rank**
Quality	1	40	53	42	86	2
Delivery	2	44	58	37	76	3
Performance History	3	7	9	5	11	7
Warranties & Claim Policies	4	0	0	2	4	13
Production Facilities and Capability	5	23	30	22	45	4
Price	6	61	80	44	90	1
Technical Capability	7	15	20	16	39	5
Financial Position	8	7	9	15	31	6
Procedural Compliance	9	2	3	2	4	13
Communication System	10	2	3	5	11	7
Reputation and Position in Industry	11	8	11	3	7	12
Desire for Business	12	1	1	0	0	21
Management and Organization	13	10	13	5	11	7
Operating Controls	14	3	4	5	11	7
Repair Service	15	7	9	2	4	13
Attitude	16	6	8	1	2	19

Impression	17	2	3	0	0	21
Packaging Ability	18	3	4	2	4	13
Labor Relations Record	19	2	3	2	4	13
Geographical Location	20	16	21	5	11	7
Amount of Past Business	21	1	1	0	0	21
Training Aids	22	2	3	2	4	13
Reciprocal Arrangements	23	2	3	1	2	19

According to Deshmukh and Chaudhari (2011), net price, quality, delivery, production facility, technical capability and financial position have become more popular after Weber's study. On the other hand, there is a high decrease in the number of articles that mention about geographical location, repair service and attitude (Deshmukh & Chaudhari 2011).

Another comparison of supplier selection criteria was done by Cheraghi et al. (2004). In this study, Weber et al. (1991)'s study was repeated and number of papers that each criterion occurred in are determined. (Cheraghi et al. 2004) Table 7 shows the result of this study. The study also includes new criteria that are not presented in the original 23 list.

Table 7. List of popular criteria in two different years (Cheraghi et al. 2004; Weber et al. 1991)

Cheraghi et al. (2004)	**Weber et al. (1991)**	**Criteria**
1	3	Quality
2	2	Delivery
3	1	Price
4	10	Repair service
5	5	Technical Capability
6	4	Production Facilities and Capacity
7	9	Financial Position
8	7	Management and Organization
9	New	Reliability
10	New	Flexibility
11	8	Attitude
12	13	Communication System
13	10	Performance History
14	6	Geographical Location
15	New	Consistency
16	New	Long-term Relationship
17	14	Procedural Compliance
18	12	Impression

19	13	Reciprocal Arrangements
20	New	Process Improvement
21	New	Product Development
22	New	Inventory Costs
23	New	JIT
24	New	Quality Standards
25	New	Integrity
26	New	Professionalism
27	New	Research
28	New	Cultural
29	8	Reputation and Position in Industry
30	13	Labor Relations Record
Passe	11	Operating Controls
Passe	11	Packaging Ability
Passe	13	Training Aids
Passe	14	Desire for Business
Passe	15	Amount of Past Business
Passe	15	Warranties & Claim Policies

According to Cheraghi et al. (2004), some criteria are no longer mentioned in the literature as critical supplier selection criteria. These are operating controls, packaging ability, training aids, desire for business, amount of past business and warranties & claim policies. On the other hand, there are some new criteria that have become popular. These are reliability, flexibility, consistency, long-term relationship, process improvement, product improvement, inventory costs, JIT, quality standards, integrity, professionalism, research and culture. (Cheraghi et al. 2004) With the help of 13 new criteria and obsoleted 6 criteria, Dickson's 23 criteria list is improved.

3.2.3 A different approach to determine criteria

Up to this point, this paper discussed the significant criteria that were only determined by number of articles each criterion occurs. In the literature, there are also a considerable amount of articles that research critical criteria in an industry or a country. These researches are done by interviews or questionnaires with purchasing managers of several companies. For instance, Kar and Pani (2014) analysed supplier selection criteria between Indian manufactures and results show that most important criteria are quality, compliance with the delivery schedule, price, financials of the supplier and e-transaction capability (Kar & Pani 2014). Malaysian manufacturers were analyzed by Sim et al. (2010), and results show that there are six major criteria in supplier selection. These are quality, delivery, cost, service, relationship and organizational status. (Sim et al. 2010) Therefore, it can be said that supplier selection criteria can be situation

dependent. According to Kar and Pani (2014), supplier selection criteria are case specific; namely, the list of criteria is modified in different situations (Kar & Pani 2014). Various authors explain that rank of criteria depends on;

- Countries (Braglia & Petroni 2000; Kar & Pani 2014)
- Industries (Braglia & Petroni 2000; Kar & Pani 2014)
- Size of the company (Kar & Pani 2014)
- Study areas (Braglia & Petroni 2000)
- Products (Cheraghi et al. 2004)
- Type of collaboration (Davidrajuh 2003)

First of all, importance of each criterion is changeable in different countries. There are considerable differences in supplier selection between developed and developing countries. Also, culture of the country has an influence on supplier selection criteria. For example, diverse cultural difference in India, affects the supplier selection criteria. (Kar & Pani 2014) Secondly, importance of criteria may change in different industries even if they are in a same country like FMCG and heavy manufacturing industry. Thirdly, size of the company also determines its sourcing and supplier selection strategy. Especially, the requirements can be very different in large companies than small and medium sized companies. Fourthly, Braglia and Petroni's research demonstrate that criteria are changeable not only with different industry and country but also in different study areas (Braglia & Petroni 2000). Fifthly, Cheraghi et al. (2004) offer that what kind of product will be purchased from the potential supplier is also a determinative factor for criteria. For example, price of more complex products is relatively unimportant; however, technical competence and capability are more important. On the other hand, when purchasing ordinary products from supplier (like bolts and nuts) price is a determinative factor. (Cheraghi et al. 2004) Finally, Davidrajuh (2003) suggests that expected and planned relationship and closeness between supplier and customer are determinative factors for supplier selection criteria. (Davidrajuh 2003)

To sum up, in the supplier selection environment, some criteria are becoming popular while others are being obsolete. However, purchasing managers choose their criteria independent from popularity and time. They select their criteria depend on their country, industry, place inside the industry they are in, their required product and their planned relationship type. The next topic will discuss the future trends in supplier selection criteria.

3.3 Evolution of supplier selection criteria

Developmental changes are happening in business environment; while companies are evolving and adapting to new industry conditions. Global competition between companies is getting more challenging and customers are becoming more demanding. Therefore, companies have to improve their products and services while reducing costs.

They have to speed up product cycles, focus more on core competencies and maximize their service levels. (Choy et al. 2004) As a result, manufacturing companies are reducing their number of suppliers and focus on fewer suppliers by building closer and long-term relationships. Today, increasingly a supplier is not only just a seller for companies; but it is also a business partner. (Sim et al. 2010) The following changes are taking place with the increase of business partners in relationships;

- Fewer suppliers are selected
- Long-term contracts instead of short term contracts
- Evolution by commitment to partnership rather than evolution by bid
- Improvement benefits are shared equally
- Close involvement in design issues
- Commitment to continuous improvement
- Problems are solved together with supplier and customer
- Information share increases
- Information technology capability is more important

(Frederick 2000; Deshmukh & Chaudhari 2011; Kar & Pani 2014)

Another improvement in supplier selection process is increase in social and environmental awareness and responsibilities (Wong et al. 2012). Although traditional companies still consider criteria like quality, flexibility as dominant criteria; there is an upcoming trend especially in large companies. Today, many large companies consider environmental issues for their businesses. Therefore, environmental factors are also being involved in supplier selection criteria. Some of popular environmental criteria are clean technology availability, use of environmentally friendly material, pollution reduction capability, green image, carbon emission, design for environment, environmental management system and environmental competencies. (Humphreys et al. 2003)

Final trend in supplier selection criteria is the effects of lean philosophy. Lean manufacturing is getting more popular in many industries. Companies adopt all the principles of lean in order to improve their processes according to it. In the beginning applications of lean, lean manufacturing techniques were known only by final assembler; but today all the direct and indirect suppliers are learning and applying lean principles. Therefore, lean manufacturing principles also change and determine the purchasing and supplying activities. In order to be lean, companies must select their suppliers by considering principles of lean. Some of the popular changes that lean philosophy suggests about suppliers are just in time delivery, total quality management and process improvement (Wong et al. 2012).

In this topic supplier selection criteria were analyzed, the next topic will give an insight to lean philosophy and changes that lean suggests.

4. LEAN MANUFACTURING

4.1 History of Lean

The origins of lean manufacturing start with Henry Ford who is the initiator of Just in Time and lean philosophy. Ford was the first person that improves the flow of production with assembly lines in 1913. (Anon 2011a; Kocakülah et al. 2008) Mass production provided Ford to produce more automobile and turn entire inventories within few days. Ford designed his production line for the Model T. Production of Model T was very effective for mass production; however, the system was not flexible. It was limited to only one specific model with a single color and all parts of the automobiles were identical. Moreover, the production heavily depended on human force and money. (Karanjkar 2007; Anon 2011a)

After World War II, Japan started to rebuild its manufacturing capability. Taiichi Ohno, founder of the Toyota Production System, was influenced by Ford's approach (Hunt 2013). He recognized the role of inventory in an efficient production. He also recognized the shortcomings of Ford production system, and then he built his own Toyota production system which allows flexibility and product variety which were lack in Ford production. (Karanjkar 2007) Toyota achieved to apply lean practices in production with variety of products. The system also allowed low cost, high quality and high performance (Anon 2011a). Toyota used several principles for its production system. These principles are mainly Just in Time (JIT), Kanban, automotive mistake proofing, and elimination of waste (the Toyota seven wastes). These principles were first applied to automobile engine manufacturing in 1950s. Secondly, they started to be applied in vehicle assembly in 1960s. Finally, principles also expanded to the supply chain in 1970s. For suppliers, Toyota prepared supplier manuals to teach lean production. (Shingo 1981; Schonberger 1982; Monden 1983) The methods Toyota applied for production of automobiles enable Toyota to produce more innovative, cheaper cars than competitors in US (Hunt 2013). During 1980s Toyota was known with continuous flow manufacturing, stockless production and world class manufacturing (Karanjkar 2007) and lean production system was previously known as the "Toyota Production System (TPS)" (Womack et al. 1990).

Lean production was introduced to world with the book "Machine that Changed the World" (Womack et al. 1990). The book was the first book about lean and it describes the principles of Toyota production system. With the help of the book lean principles started to be adopted by Western manufacturers (Hines & Rich 1997). First adoption of lean was limited with few processes. These are: shop floor techniques of

lean, small batch production, standardized work and Kanban. However, first lean adopters hardly sustained lean principles. (Yamamoto & Bellgran 2010) They could not apply lean principles in their culture and mind-set and many lean attempts were not completely efficient (Holweg & Pil 2001). During mid-1990s, the link between supply chain and lean was introduced. Pull mechanism extended to partners in a supply chain (Hines & Rich 1997) In 1996, Womack and Jones defined five principles of lean thinking as a guide. These five principles were:

1) Identification of customer value
2) The management of the value stream
3) Developing the capability of flow production
4) The use of "pull" mechanism to support flow of materials
5) The pursuit of perfection through reducing all forms of waste in production system (Womack & Jones 1996)

This topic aims to introduce lean concept by its brief history. In the following topic, the principles of lean will be described in detail and evolution of lean will be analyzed.

4.2 Lean production

4.2.1 Explanation of lean

There is no certain explanation of lean in the literature. According to Smeds (1994), lean is simplifying processes and supporting developments and innovation (Smeds 1994). Bayou and Korvin (2008) define lean as dynamic, long-term and integrative concept (Bayou & Korvin 2008). Actually, lean production is a conceptual framework that has some principles and techniques. (Monczka et al. 2009) Using these techniques and principles, lean manufacturers target improvement and growth. The objective of lean practices is expressed by various authors, some examples are the followings:

- Building a culture for continuous improvement and organizational learning (Yamamoto & Bellgran 2010)
- Increasing productivity, reducing costs, reducing lead times and improving quality (Sanchez & Perez 2001; Karlsson & Åhlström 1996)
- Reducing lead time, cost of quality, process changeover while increasing labor productivity (Bhasin & Burcher 2006)
- Minimizing all kind of waste while maximizing value for the customers (Anon 2011b)
- Providing efficiency and effectiveness together (Bayou & Korvin 2008)

It can be summarized that lean production aims continuous improvement to serve best value for customer and achieves this with reducing costs, lead times, wastes while enhancing quality and productivity.

Womack et al. (1990) claim that lean is the best of craft production and mass production (Womack et al. 1990). Lean is superior to mass production; because, lean uses less than mass production in terms of human effort, manufacturing space, investment in tools and inventory; and results in fewer faults and produce more variety of products (Bayou & Korvin 2008).

4.2.2 Characteristics of lean

Lean manufacturing has many indicators that have been used in lean companies. Since lean is evolving over time, these indicators and requirements have been increased. The most common lean characteristics are the followings:

- Elimination of zero-value activities (Hines & Taylor 2000; Howell 2010; Karlsson & Åhlström 1996; Sanchez & Perez 2001)
- Continuous improvement (Sanchez & Perez 2001; Karlsson & Åhlström 1996; Bhasin & Burcher 2006)
- JIT production and delivery (Sánchez 1991; Jones 1992; Cooney 2002; Karlsson & Åhlström 1996; Ahlström & Karlsson 1996; Oliver et al. 1993; Wu 2003)
- Pull instead of push (closely related to JIT) (Karlsson & Åhlström 1996; Ahlström & Karlsson 1996; Wu 2003)
- Multi-functional teams (Sanchez & Perez 2001; Karlsson & Åhlström 1996; Ahlström & Karlsson 1996)
- Integrated functions (closely related to multi-functional teams) (Karlsson & Åhlström 1996; Ahlström & Karlsson 1996)
- Flexible information systems (Sanchez & Perez 2001; Karlsson & Åhlström 1996; Ahlström & Karlsson 1996)
- Zero defects (related to JIT and multi-functional teams) (Karlsson & Åhlström 1996; Ahlström & Karlsson 1996; Levery 1998)
- Supplier integration (Sanchez & Perez 2001)

First of all waste is something that customers are not willing to pay for it (Karlsson & Åhlström 1996). Lean manufacturing aims to remove everything that does not add value to customer. Waste can be both from inside of a company and between companies. (Hines & Taylor 2000) There are seven wastes that must be eliminated for lean production, these are:

1) Over production
2) Defective parts

3) Inventory
4) Inappropriate processing
5) Transportation
6) Waiting
7) Unnecessary motion

Overproduction means producing more than need or earlier than required time. It results in poor flow of information and goods. Also causes products to stay idle and excessive inventory. (Hines & Taylor 2000; Howell 2010) Defective parts are also considered as waste since they have no value. They cause rework, delays, more production cost (Howell 2010), errors in paperwork, quality problems, poor delivery performance (Hines & Taylor 2000) and decrease productivity (Karlsson & Åhlström 1996). Inventory is the most important source of waste (Karlsson & Åhlström 1996). Level of inventory must be reduced to its minimum to apply lean efficiently. Unnecessary inventory can occur because of excessive storage, delay of information, delay of products and causes cost and poor customer service (Hines & Taylor 2000). Excessive inventory can be also caused because of overproduction (Howell 2010). In order to prevent inventory waste, down time of the machines, lot sizes, work-in-progress and set-up times can be reduced (Karlsson & Åhlström 1996). Inappropriate processing is processing using wrong tools, procedures, systems (Hines & Taylor 2000) or using more steps than need to complete a process (Howell 2010). Usually simpler approaches are more effective and creates minimum waste (Hines & Taylor 2000). Transportation waste results from excessive movement of people, information or goods. These movements do not add value; and time, effort and cost are consumed unnecessarily. (Hines & Taylor 2000) Automated transfers can be used if transfer cannot be avoided anywise (Karlsson & Åhlström 1996). Waiting waste originates in idle materials, machines or workers that wait without actual work. This results in poor flow and long lead times. (Hines & Taylor 2000; Howell 2010) Finally, poor workplace and poor ergonomics causes unnecessary motion (Hines & Taylor 2000). Besides, tools, materials and human move excessively which consumes more time (Howell 2010).

As it was also mentioned in the objective of lean manufacturing part, continuous improvement is core principle of lean. Continuous improvement means looking for opportunities constantly for improvements in products, services and processes (Sanchez & Perez 2001). Enhancing quality, reducing cost, improving delivery service and developing designs are some examples of continuous improvement (Bhasin & Burcher 2006). Employee and management team involvement in processes contributes to improvements (Karlsson & Åhlström 1996). Involvement of workers to identify and adjust defective parts in production process is an improvement for a company. Because, by this way, factory needs few quality control employees (Sanchez & Perez 2001). Continuous improvement requires multifunctional teams which will be explained later (Karlsson & Åhlström 1996).

Just in time (JIT) means producing or providing right product or part, right quantity and at the right time (Karlsson & Åhlström 1996; Sanchez & Perez 2001). The objective of JIT is providing one part exactly when it is needed. JIT works on the principle of small-lot production and JIT delivery. JIT improves inventory turnovers and causes less inbound inventory. (Wu 2003) Determinants of JIT are reduced lot size, buffer size and order lead time (Karlsson & Åhlström 1996). Cooney (2002) claims that, JIT flow is at the center of lean production. Because it contributes to waste reduction, delegation of responsibilities to front line workers, continuous improvement activities, value adding activities. (Cooney 2002) JIT also integrates automation equipment with production information flow (Sanchez & Perez 2001). JIT is closely related to pull system and waste reduction (Pettersen 2009; Karlsson & Åhlström 1996). Pull strategy must be applied as a result of JIT; because, the demand is needed to be known and stability must be provided for JIT.

Multifunctional teams are needed in lean production. To establish multifunctional teams, numbers of people who are capable of perform different tasks needs to be increased. Each team has the responsibility of doing all tasks and solves problems in production flow. Training is required for each member to learn and perform different tasks. (Sanchez & Perez 2001; Karlsson & Åhlström 1996) Training includes material handling and control, purchasing, maintenance and quality control. With multifunctional teams, flexibility increases while vulnerability decreases. Also, there is no dependency to a single person. Since teams can perform different tasks, responsibilities decentralize. Therefore, the level of hierarchy diminishes in firms. Integrated functions in firms can be seen because of multifunctional teams. These teams have more work content then traditional teams. (Karlsson & Åhlström 1996)

Flexible information system is necessary for lean manufacturing; especially for multifunctional firms; because, information must be provided continuously and directly to employees. Horizontal and vertical information systems must be organized for smooth flow of information (Ahlström & Karlsson 1996; Karlsson & Åhlström 1996). Flexible information systems decrease hierarchical levels and allow diffusion of information to all levels (Sanchez & Perez 2001).

Zero defects mean all parts and products must be free of fault. This can be achieved by shifting product control to process control. Because, lean production focuses on preventing faults instead of finding them and quality assurance must be responsibility of everyone not only one department. Preventive manufacturing has also an important effect on quality, quantity and costs. (Levery 1998; Karlsson & Åhlström 1996)

Supplier integration is also another important characteristic of lean philosophy. Integration improves lean companies completely; but some departments like R&D and logistics are benefit from it more than others. With the help of integration, better information exchange is provided, customer company can involve in component designs and suggestions can be shared. Lean also supports reducing number of suppliers and focusing on few suppliers with long term contracts. (Sanchez & Perez 2001) Lean

effects on supplier and supply chain will be analyzed and described in the next topic in detail.

Lean is evolving over time and new characteristics are emerging. Therefore, there are also various more characteristics of lean manufacturing, but they are related to previously mentioned core characteristics in some way. For example, lean supports cellular manufacturing which reduces transport and waiting time (Bhasin & Burcher 2006) and requires multi-functional teams (Ahlström & Karlsson 1996). Lean also offers single piece flow in operation to complete a product without interruption and single minute exchange of dies in order to eliminate delays for change over. Process mapping is also another trend in lean manufacturing which gives a detail map of order fulfillment process. (Bhasin & Burcher 2006) Finally, management accounting system of a lean company should support lean production (Ahlström & Karlsson 1996).

As it was mentioned before, lean manufacturing has many indicators and characteristics that are applied. These practices have been evolving with lean and new ones are emerging. Most of lean practices are related with each other or supporting each other. In this topic most of the characteristics were explained and there are still few characteristics that are not used widely. Table 8 represents these characteristics and their collective terms in order to understand their relations.

Table 8. Grouping lean characteristics (Pettersen 2009)

Collective Term	**Specific Characteristics**
Just in time	Production leveling
	Pull system
	Takted production
	Process synchronization
Resource reduction	Small lot production
	Waste elimination
	Setup time reduction
	Lead time reduction
	Inventory reduction
Human relations management	Team organization
	Cross training
	Employee involvement
Improvement strategies	Improvement circles
	Continuous improvement
	Root cause analysis
Defects control	Automation
	Failure prevention
	100% inspection
	Line stop
Supply chain management	Value stream mapping/flowcharting
	Supplier involvement
Standardization	Housekeeping

	Standardized work
	Visual control and management
Scientific management	Policy deployment
	Time/work studies
	Multi manning
	Work force reduction
	Layout adjustment
	Cellular manufacturing
Bundled techniques	Statistical quality control
	Preventive maintenance

4.2.3 Lean enterprises

Lean requirements are applicable to any enterprise and industry (Womack et al. 1990). In order to be lean, entire activities in an enterprise must show lean characteristics. According to the model of Karlsson and Åhlström, a lean enterprise consists of lean development, lean procurement, lean manufacturing and lean distribution (Karlsson & Åhlström 1996). Figure 4 shows this model with its appropriate characteristics. Lean also includes inventory and quality control, industrial relations, labor management, supplier manufacturer practices that are different from traditional approaches (Wu 2003). Lean has two levels which are strategic and operational; and lean adoption requires technological and organizational changes (Hines et al. 2004).

It should be bear in mind that since lean aims maximizing customer value, a lean company must focus on customer value. Therefore, adoption of lean must start from creating value for customers. Value is created by reducing waste and cost; and adding features and services. The cost-value proportion determines the customer willingness to buy a product or a service. (Hines et al. 2004). Womack and Jones created a framework for building lean enterprise. The framework includes four phases which are preparing for organization and systems, creating organization, installing business systems and completing the transformation. (Womack & Jones 1996) The steps of the building and time frames can be seen in Table 8.

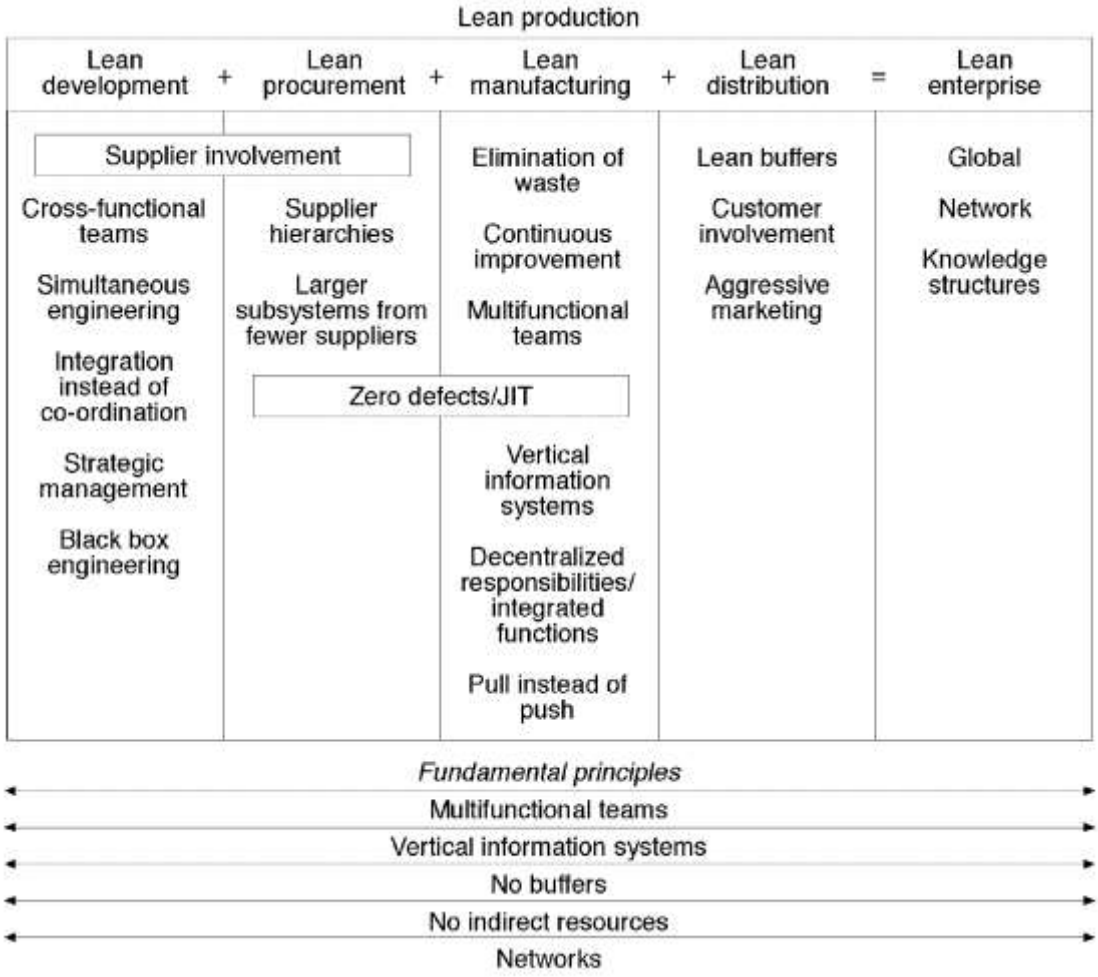


Figure 4. Karlsson & Åhlström's model for lean enterprise (Karlsson & Åhlström 1996)

Table 8. Time frame and steps of lean enterprise creation (Womack & Jones 1996)

Phase	**Specific steps**	**Time frame**
Get started	Find a change agent	First six months
	Get lean knowledge	
	Find a lever	
	Map value streams	
	Begin kaikaku	
	Expand your scope	
Create a new organization	Reorganize by product family	Six months through year two
	Create a lean function	
	Devise a policy for excess people	
	Devise a growth strategy	
	Remove anchor-draggers	
	Instill a "perfection" mind-set	
Install business systems	Introduce lean accounting	Years three and four
	Relate pay to firm performance	

	Implement transparency	
	Initiate policy deployment	
	Introduce lean learning	
	Find right sized tools	
Complete the transformation	Apply these steps to your suppliers/customers	By the end of year five
	Develop global strategy	
	Transition from top-down to bottom-up improvement	

According to Bayou and Korvin (2008), leanness of a company can be measured by;

- Assessing waste reduction and output improvement
- Identifying and analyzing cost cutting programs
- Assessing corporate performance (Bayou & Korvin 2008)

With the help of above assessments and analyses, leanness of an enterprise can be understood and improvements can be done.

In this topic, organizational practices and changes were discussed for lean manufacturing. Next topic will analyze the principles and changes that lean philosophy requires in supply chain.

4.3 Lean effect on suppliers and supply chains

As it was mentioned in the previous topics, suppliers have great importance on companies; and suppliers of lean organizations must support lean practices. There are considerable differences between lean suppliers and traditional suppliers. This topic will compare lean suppliers with traditional suppliers and give an insight into effects of lean philosophy on suppliers.

Lean manufacturing starts from final assemblers and diffuse to suppliers through the chain; because, proper lean production requires lean supply which can be only provided by lean suppliers. (The “lean supply” concept is adopted from “lean production” (Xu et al. 2008)) Therefore when an enterprise starts to apply lean practices, it must also consider its suppliers.

From the point of supply chain, in order to be lean completely, all supply chain should be lean. (Bhasin & Burcher 2006) There are some basic characteristics of supply chain that are crucial for lean supply. For example, lean production requires simplified, optimized and streamlining supply chain and in order to have a sustainable supply chain, supplier improvements must be supported both internally and externally (Palevich 2012). The following sub-topics will analyze and compare lean supply in terms of relationship, production performance and logistics performance.

4.3.1 Effects of lean supply on supplier relationship

As it was stated before, relationship with suppliers plays an important role on efficiency of processes inside a company. Lean manufacturing also places particular importance on supplier relations. Lean requires close coordination and collaboration with suppliers and customers. (Xu et al. 2008). Well-structured, high involvement, tight and integrated relationship is an optimal relationship that lean offers. This kind of relationship brings high performance to the company and the supply chain. (So & Sun 2010; Xu et al. 2008). Performance of lean supply chains is much higher than traditional supply chains. The table 9 demonstrates some relationship differences between lean and traditional supply chain.

Table 9. Differences in means on customer-supplier relationships (Wu 2003)

Items	**Lean**	**Non-lean**
Business relationship (years)	14.2	9.6
Length of contract (years)	4.2	3.7
Relationship based on mutual trust	3.48	3.13
Percent participation in supplier quality certification program	81	68
Percent of products accepted as good without inspection	95.2	90.4
Percent of sole source	92	88
Percent of emphasis on delivery performance by customer	44	40

It can be seen from the first two raw of the Table 9 that with lean suppliers, length of relationship and contract are longer compared to traditional suppliers. Level of trust seems more important for lean companies, which leads to increase in percent of uncontrolled products. All in all, the table demonstrates that lean companies establish closer and collaborative relationships with suppliers which are supported by mutual trust.

While building close relationships, customers and suppliers share processes and cost information. The most common way to share processes is customer involvement. Customer involves in supplier's processes; therefore, supply chain works without boundaries. As a result of shared environment, damages and benefits can be shared between parties (Oliver et al. 1996). Xu et al. also states that success of lean manufacturing highly depends on supplier and customer integration and sharing gains from mutual investments (Xu et al. 2008) A well information flow is crucial to establish this kind of close and shared relationship. Lean manufacturing enhances supply chain in terms of information flow between customer and supplier. Flow of information in lean supply is frequent, rapid and integrated compared to traditional supply (Oliver et al. 1996; Wu 2003). Table 10 compares lean and non-lean companies in terms of information flow.

Table 10. Differences in means on use of information communication (Wu 2003)

Items	**Lean (%)**	**Non-lean (%)**
Order processing	81	86
Shipment tracking	71	54
Advanced shipment notice	100	89
Communication	86	84
Shipment schedule	90	84
Production schedule	44	30

The table shows that different kind of information is shared more in lean organizations. Sharing information about shipment and production schedule; tracking shipments are some examples of improved communication.

Close, integrated relationship and frequent flow of information provides additional advantages to organizations. Some of lean advantages to buyer supplier relationship is reduction of defects, reduction of design changes, rapid new product development, improved quality, efficiency, stabilized supply chain and cost transparency (Mollenkopf et al. 2010). Lean suppliers also have the ability to guarantee some functions like delivery, quality and cost as a result of close relationship. Lean supply provides open communication and coordination which provides quick respond to problems. Moreover, close relationship of lean brings high motivation and trust in supply chain (Simpson & Power 2005).

Since lean requires continuous improvement, supplier relationship must also improve continuously. Assessments are one of the common ways for supplier-customer relationship improvement. Customers monitor and evaluate their suppliers regularly to find out areas that need improvement (Lamming 1996). Reliability of suppliers is also another measurement of successful relationship. Especially, cost, quality and delivery must be reliable for a stable relationship. (Macduffie & Helper 1997)

4.3.2 Effects of lean supply on supplier production

Production is another developed activity with lean as well as relationship with supplier. Lean manufacturing improves suppliers' productivity and brings performance benefits to both parties. Base of productivity starts from the first principle of lean; waste reduction. As it was explained before, lean manufacturing requires elimination of all kind of non-value activities. In a supply chain, waste also does not have any value and must be eliminated. For a lean supply chain the amount of inventories must be kept at minimum which helps cost reductions in supply processes. This can be achieved by suppliers which can provide JIT production (Wu 2003). Since JIT production requires pull system, all supply chain must be pull instead of push.

There is a significant difference between lean suppliers and traditional suppliers in production performance. This can be seen in Table 11.

Table 11. Differences in means on production (Wu 2003)

Items	**Lean**	**Non-lean**
Inventory on the road (shifts)	2	2.8
Inventory maintained at the customer's site (shifts)	3.5	5
Delivery lead time (shifts)	2.7	5.4
Machine mobility (shifts)	40.6	23.5
Labor flexibility	2.4	1.8
Frequency of die changes	3.3	3
Quality responsiveness (min)	3.5	7.5
Frequency of preventive maintenance	2.4	1.9
PM schedule followed	3.1	2.6
Percent of PM skipped	11.1	28.7
Percent unscheduled downtime	5.8	8

According to the table lean suppliers are more flexible, rapid, scheduled and organized. Production quality of lean suppliers is better. This is most likely result from less downtime of machineries and high frequency of preventive maintenance. Inventory management of lean suppliers is far better in lean suppliers which show effective use of JIT and waste reduction principle.

Companies that adopt lean practices need to eliminate suppliers and find out the ones which can provide required attention on production and product development. (Wu 2003) The selected suppliers must apply customer requests for changes in products or processes. Integration with suppliers provides a good information flow and improves production efficiency. Therefore, performance and quality increases while total cost decreases.

4.3.3 Effects of lean supply on logistics performance

Lean aims providing value to customer and the value must be transferred to final customer in the most efficient way. Logistic performance is an important parameter for efficient value chain. Lean suppliers apply lean principles which provide numerous advantages in terms of transportation systems, distribution and logistics. According to Wu (2003), transportation systems are improved with lean manufacturing principle of JIT. With JIT, deliveries are frequent with small batches, transfer of materials synchronized with other production activities and transportation becomes more efficient. (Wu 2003)

There is a significant differences between lean and traditional distribution performance (Wu 2003). Table 12 lists some of the major differences.

Table 12. Differences in means on transportation systems and logistics (Wu 2003)

	Items	Lean	Non-lean
Transportation systems	Shipping distance (miles)	408	451
	Percent of shipments delivered daily	91	71.5
	Loading time (mins)	41	83
	Percent of on-time pickups required	99	97.9
	Percent of on-time pickups achieved	91	83.2
	Percent of on time deliveries required by customer	100	94.5
	Percent of transportation costs of total costs	1.47	1.78
	Percent of full truck-loads filled	57.4	63.8
Logistics performance	Percent of on-time staging	96.6	93.4
	Percent of late deliveries	1.35	2.15
	PPM defective products shipped to customer	287	958
	PPM products require rework or scraping	18.729	66.351

According to the table, lean customers require 100% on time delivery from their suppliers. Requirement of on-time pickups nearly equal for lean and non-lean suppliers; however, lean suppliers provide better performance on achieve this requirement. Percent of transportation cost is lower with lean suppliers in spite of daily deliveries are more and percent of full truck-loads are low with lean suppliers.

When it comes to logistics performance, percent of on-time deliveries are higher for lean suppliers. Amount of defective products shipped to customer and reworked or scraped products are much lower than non-lean suppliers.

All in all, lean supply chain is more competitive with responsive demand change, delivery performance and production performance. For lean organizations it is essential to work with lean suppliers. There are several methods to obtain lean suppliers. Simpson and Power (2005) describes three methods, these are;

- Vertically integration
- Switching from non-lean suppliers to lean one
- Developing lean capabilities of existing suppliers.

Even though switching to lean suppliers may seem the easiest solution, researches show that switching is not the best option. First of all, switching causes high transaction costs; secondly, it also results loss of goodwill; thirdly, it is hard to build the same or better relationship with a new supplier. Therefore, lean companies prefer vertical integration or training existing suppliers for lean practices. (Simpson & Power 2005)

5. AUTOMOTIVE INDUSTRY

5.1 Overview of the industry

Automotive industry consists of companies that play role on production and selling of motor vehicles. The industry launched at the beginning of 1900s and today it is one of the largest industries in the world. There is a high competition in the industry and high entry barriers for new entrants (Mushtaq & Sarwar 2011). This situation makes the industry geographically concentrated.

Geographical concentration results from the global automotive trade. Many countries that produce cars export large share of the production (Haugh et al. 2010). In the following figure import and export differences can be seen. While USA has a trade deficit, Japan has very large trade surplus in the industry (Dicken 2011).

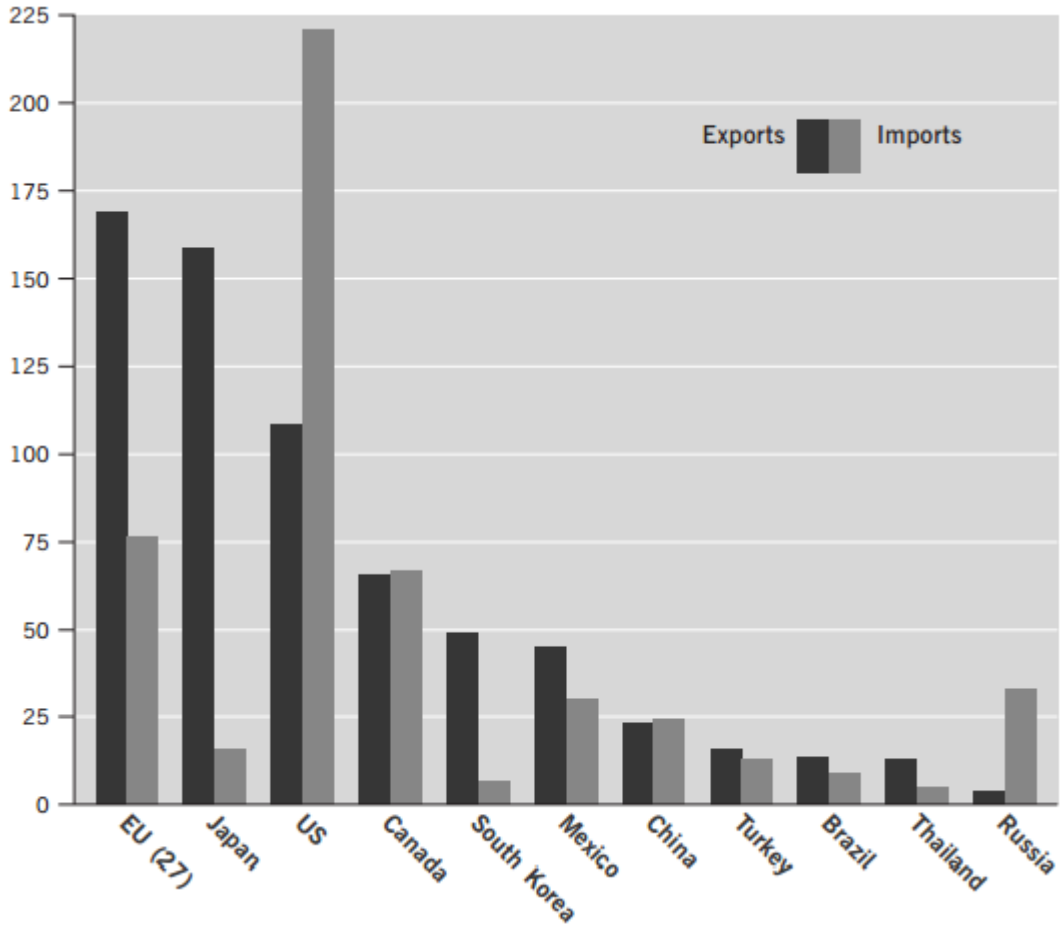


Figure 5. Leading exporters and importers in the automotive industry (Dicken 2011)

The global automotive industry consists of very large corporations and they mainly assemble final product by bringing together variety of components. Major supplied materials are steel rubber, electronics, plastic glass and textile. Production is strongly concentrated and most of the production is in seven countries. Figure 6 shows the global production of passenger cars. (Dicken 2011)

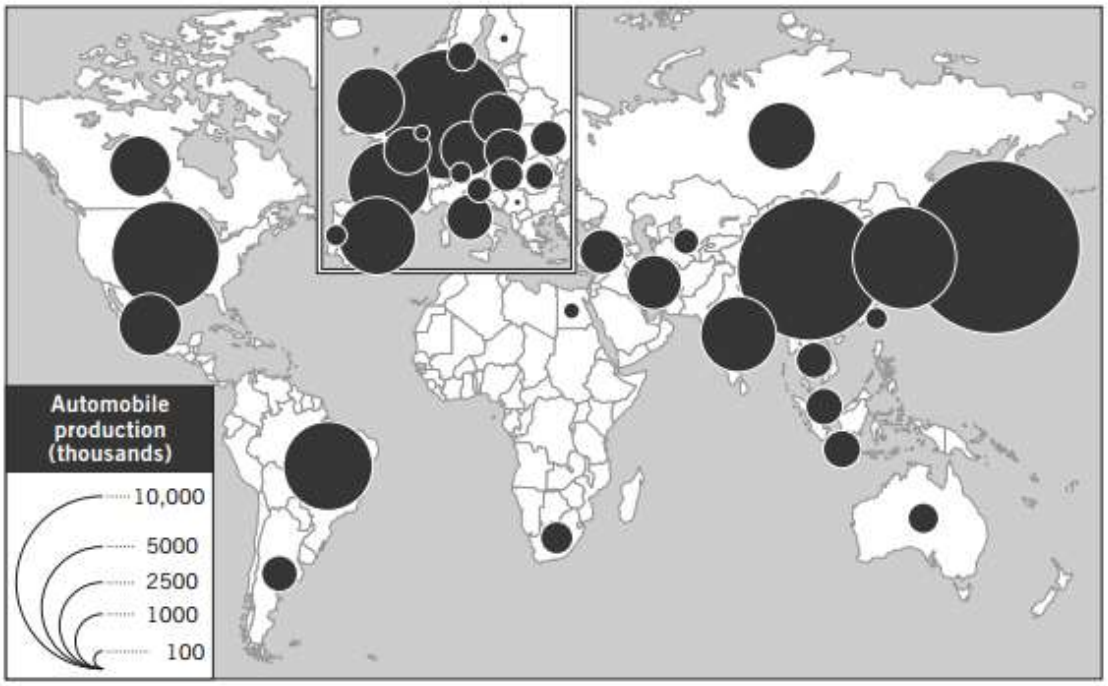


Figure 6. Global production (Dicken 2011)

Today, many automotive assembly plants in the world have high degree of outsourcing and sequential deliveries (Aláez-Aller & Longás-García 2010). Automotive industry consists of vehicle assembly and parts sectors. Lead firms in the industry carry out product design, production of engines and transmissions and final vehicle assembly in their own plants. They have power in the chain and they can control and coordinate the supply chain. (Sturgeon et al. 2009) Figure 7 shows the basic structure of an automotive production chain. The left section of the figure lists the major supplying industries. The center identifies the three major processes before the final assembly: the manufacture of bodies, components, and engines and transmissions.

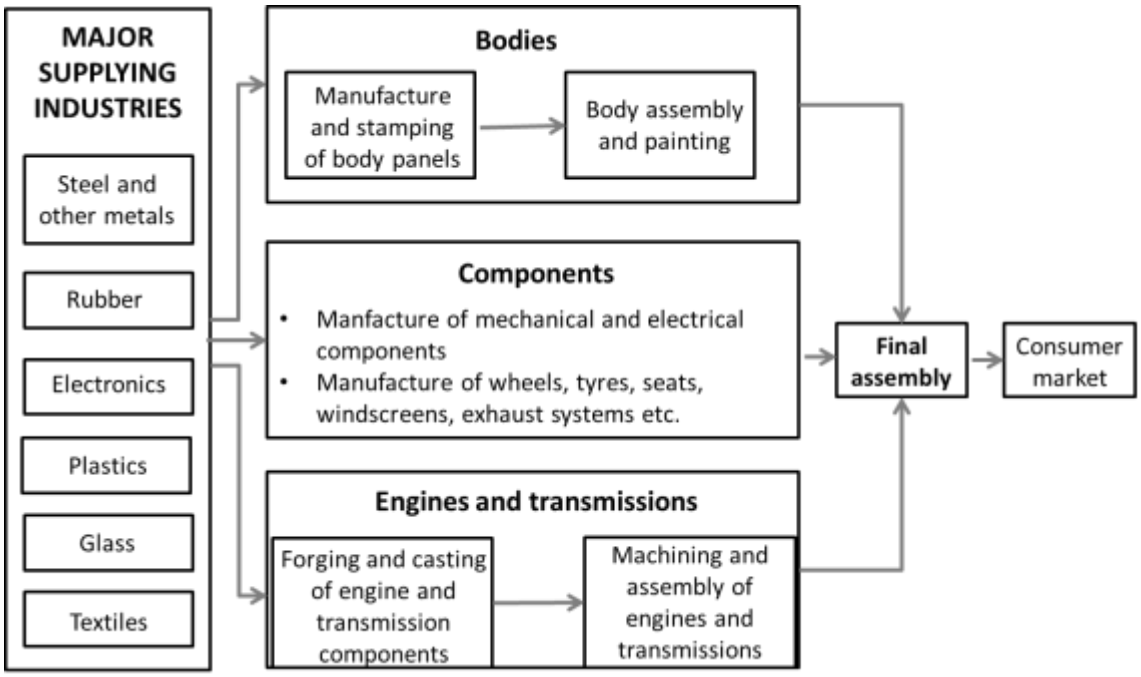


Figure 7. The basic automotive production chain (Dicken 2003)

Various levels of suppliers in automotive industry can be also divided as three tiers. The production flows from three tiers to final producer, OEM. (Jaklic et al. 2005)

- First-tier suppliers
- Second-tier suppliers
- Third-tier suppliers

First-tier suppliers supply complete systems like brake systems directly to OEMS. They provide high level of product development. Second-tier suppliers supply modules and component parts to first-tier suppliers. Therefore, first-tier suppliers provide complete systems for vehicle manufacturers. Finally, third-tier suppliers supply raw materials and generic engineering components for the supply chain.

Turkish automobile industry is considered new compared to world. Development of Turkish automotive industry first started in 1950s. In 1960s, foreign car manufacturers built plants with joint ventures. Renault, Ford and Fiat are the first investors in Turkey. During 1990's Toyota, Honda, Hyundai, Isuzu and Mercedes-Benz entered the market. (Mey 2010) Automotive industry plays an important role on Turkish economy (Deloitte 2010). It is the third largest sector and the most innovative sector in Turkey (Kannan & Tan 2006).

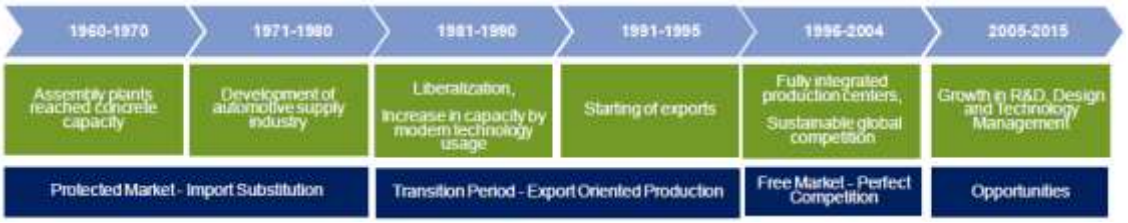


Figure 8. Timeline of the development of Turkish automotive industry (Deloitte 2010)

Currently, there are 22 automotive manufacturers in Turkey. Today, the automotive sector is the leading exporter. Around 75 percent of vehicle production is exported mainly to Europe. Toyota, Ford Otosan, Tofas-Fiat and Oyak-Renault are the top ten exporter companies in Turkey. These four manufacturers accounted for approximately 90 percent of all vehicle manufacturers in Turkey. (Deloitte 2010) Figure 9 shows total production and total export between 2004 and 2014. (OSD 2014)

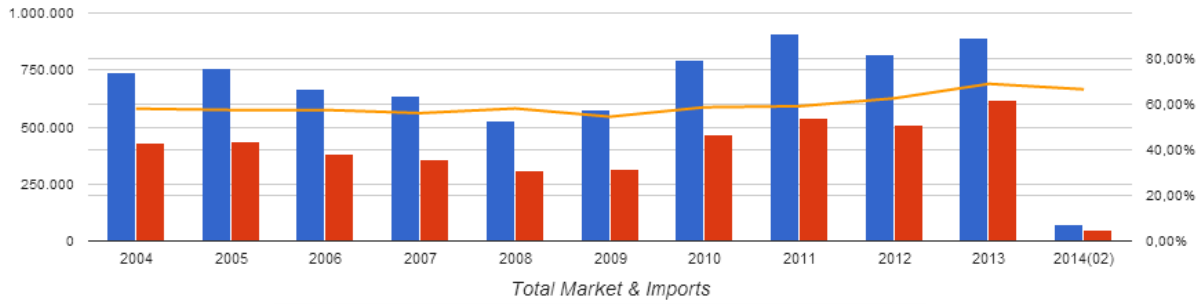


Figure 9. Total production and total export in Turkey over years (OSD 2014)

According to Automotive production in 2013, Turkey is one of the twenty largest automotive producers in the world. Figure 10, shows global vehicle production by countries. Total world vehicle production in 2013 is about 87 million and Turkey's production is about 1.1 million. (Anon 2013)

Baskak and Mihcioglu (2004) list the strengths and weaknesses of Turkish automotive sector. According to them;

Strengths of Turkish automotive industry are:

- Closeness to European market, Turkic republics and middle-east countries.
- Current capacity and high potential supply industry
- Power of foreign partners
- Technological knowledge and strong quality management
- Turkey as being the production center of automotive by foreign partners
- Export experience
- Integration with European Union
- Developed distribution and marketing organizations (Baskak & Mihcioglu 2004)

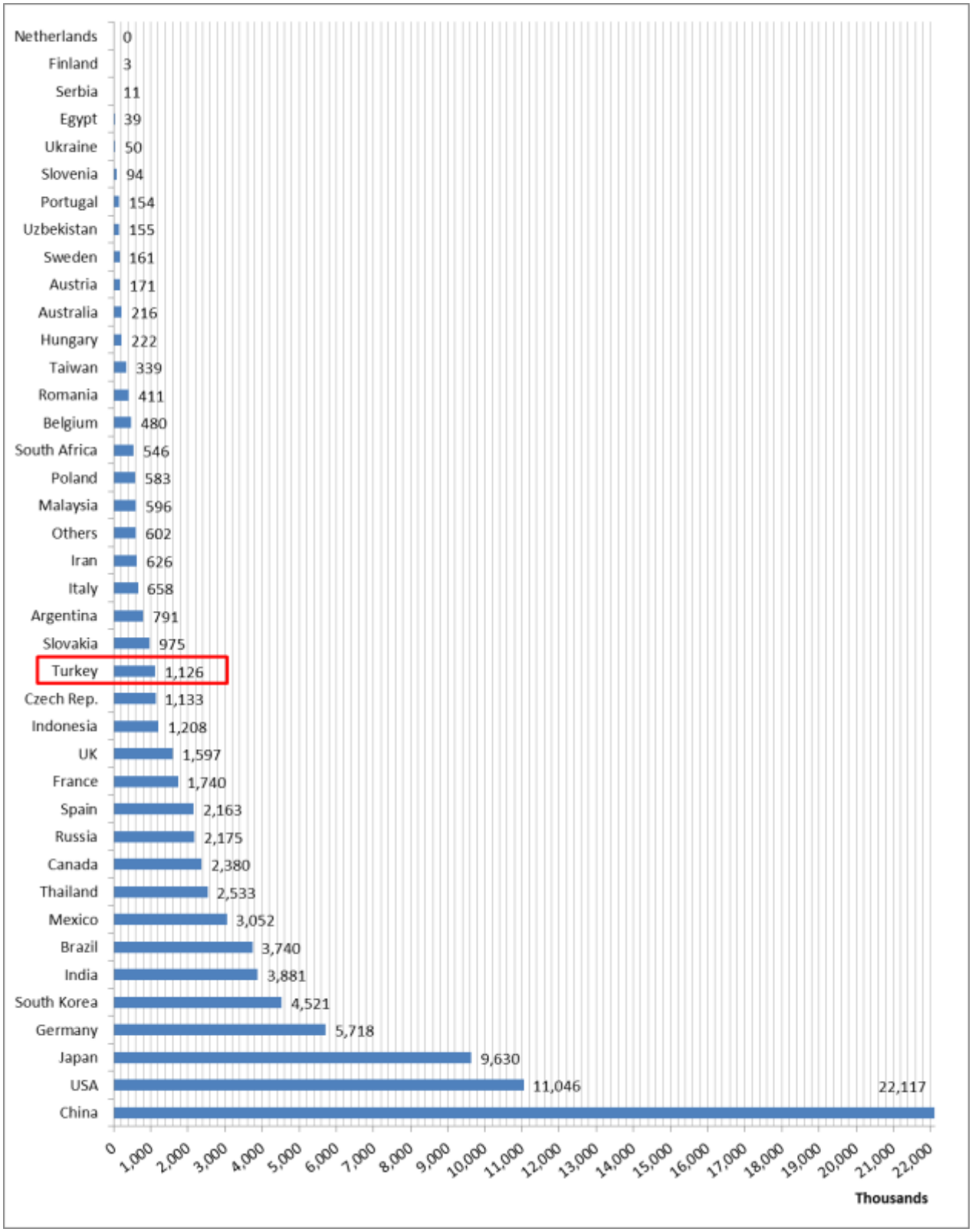


Figure 10. Global Automotive production in 2013 (Anon 2013)

Weaknesses of Turkish automotive industry are:

- Overcapacity
- Excessive number of companies in the industry
- Unstable domestic market
- Production with high costs because of using low capacity
- Inefficient organization between buyers, suppliers and marketing organizations
- Lack of technical background
- Raise in exports
- High output taxes (Baskak & Mihcioglu 2004)

Strengths and weaknesses show that automotive industry in Turkey is a developing industry by following and adapting procedures from other countries. Turkey has an high potential for export and need more experience in order to be a stable market.

5.2 Characteristics of the automotive industry

The main characteristics of automotive industry are;

- Dependency on R&D
- Influence on other industries
- Dependency on FDI
- Concentrated industry
- Strong regional structure
- Specific parts for each vehicle model

First of all, research and development activities are seen very fluently in automotive industry. Every company in the sector has to improve its technology continuously. The main reasons of this situation are fierce competition in the market and change in customer demand. (Baskak & Mihcioglu 2004)

Secondly, automotive industry improves so many other industries, since one product consists of many different and tailored parts. As it was mentioned before, automotive OEMs have many suppliers from various industries like iron-steel, plastics, rubber, petrochemical, glass, textile, electric, electronic and machine production. (Baskak & Mihcioglu 2004)

After 1980s, there have been a dramatic increase in FDI (Foreign direct investment), global production and cross border trade in many industries, including automotive. Large FDI flows have seen in countries like China, India and Brazil to supply local markets and export back to developed countries. Supply chain activities have improved and outsourcing became more important by increase in globalization. Therefore, developed countries involved in FDI and developing countries increased their capabilities. (Sturgeon et al. 2009)

Automotive industry is considered as extremely concentrated; because there are few giant firms which have high power against smaller firms. These giant firms were enhanced by acquisitions and merges. This extremely concentrated structure causes high entry barriers to the industry and limits smaller firms to upgrade prospects. Today, there are eleven lean firms in automotive industry from countries Japan, Germany and USA. These eleven firms dominate production in the market. (Sturgeon et al. 2009; KPMG 2002)

Another characteristic of automotive industry is its strong regional structure. Many manufacturing industries have developed global-scale patterns of integration. Even though automotive has integrated globally, it developed strong regional-scale patterns of integration. (Sturgeon et al. 2009)

Parts and sub-systems in automotive industry are not generic but highly specific to particular vehicle and model. In many industries like apparel or electronics, supplied parts are generic and can be used for various different products (like thread, memory chips and microprocessors). These unique parts make suppliers more valuable because one supplier is often the sole source of a specific product. Therefore, relationship with suppliers in automotive industry is more close and collaborative. (Sturgeon et al. 2009)

The vehicle design and development activities are placed near the headquarters of lead firms; and suppliers that take a role on design process, establish their centers close to their customers. Buyer supplier relationship and design activities span multiple production regions; because, products are tailored to local markets and parts are manufactured in multiple regions. Therefore, in automotive industry, local, national and regional value chains are nested. This can be seen in Figure 11. (Sturgeon et al. 2007)

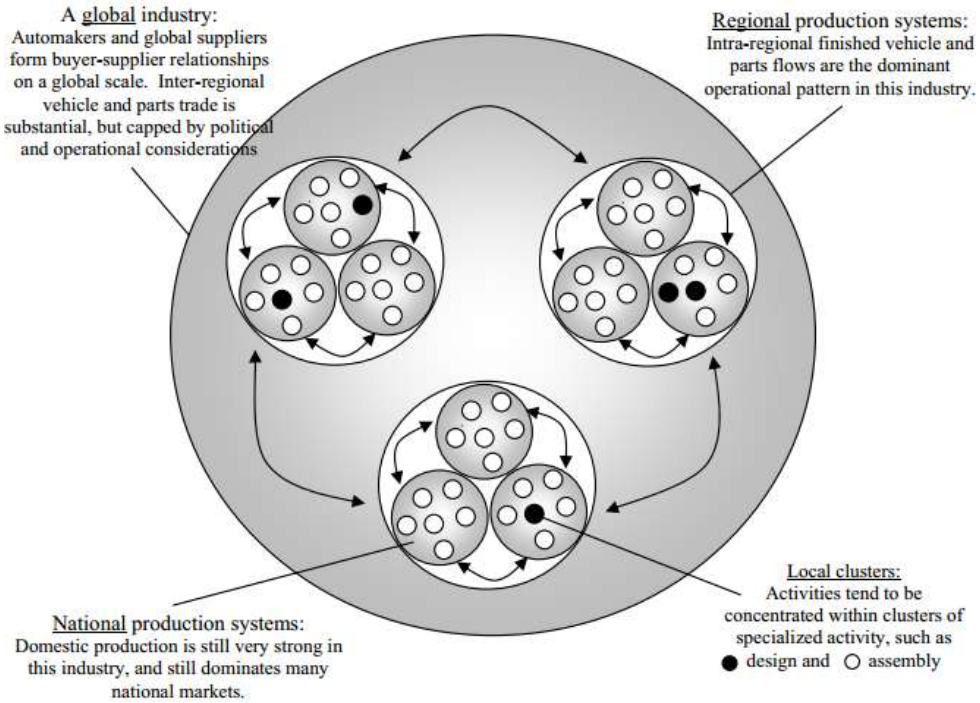


Figure 11. The nested geographic and organizational structure of the automotive industry (Sturgeon et al. 2007)

5.3 Supplying in the automotive industry

	Raw material supplier	Component specialist	Standardiser	Integrator
Focus	A company that supplies raw materials to the OEM or their suppliers	A company that designs and manufactures a component tailored to a platform or vehicle	A company that sets the standard on a global basis for a specific component or system	A company that designs and assembles a whole module or system for a car
Market presence	• Local • Regional • Global	• Global for 1st tier • Regional or local for 2nd, 3rd tiers	• Global	• Global
Critical capabilities	• Material science • Process engineering	• Research, design and process engineering • Manufacturing capabilities in varied technologies • Brand image	• Research, design and engineering • Assembly and supply chain management capabilities	• Product design and engineering Assembly and supply chain management capabilities
Types of components or systems	• Steel blanks • Aluminium ingots • Polymer pellets	• Stampings • Injection moulding • Engine components	• Tyres • ABS • Elect. control unit	• Interiors • Doors • Chassis

Figure 12. Segmentation of supplier roles in the automotive industry (Veloso 2000)

The supply system in automotive industry is more functionally segmented. Figure 12 shows the supplier segments as raw materials suppliers, component specialists, standardizers and integrators. While raw materials suppliers and component specialist were known previously; the standardizers and the integrators have emerged later in the industry. Each of the suppliers has its own capabilities in the chain. (Dicken & Henderson 2003)

Procurement is very crucial in the automotive industry since an automotive consists of approximately 15,000 components (Wei & Chen 2008). Automotive OEMs prefer to outsource their non-core processes to suppliers in order to be more responsive and to be influenced less from demand fluctuations (Harrison 2004).

Supply strategy of automotive assembly plants provides them a competitive advantage. Therefore, each automaker determine supply strategy for types of suppliers like close co-operation or fierce competition between suppliers. Diffusion of lean production also influenced supply activities of automotive companies. (Aláez-Aller & Longás-García 2010)

Production in motor companies is considered more complicated than others. Technological complexity in automotive parts is increasing with new developments. While this situation influences bargaining power; automotive OEMs need close collaboration with their suppliers. Furthermore, automotive suppliers have high technological capability and there is a well-established co-ordination in the assembly

chain. Therefore, buyer is relatively vulnerable and financial solvency of suppliers is essential. (Wei & Chen 2008; Aláez-Aller & Longás-García 2010).

Supply chain of automotive industry has some challenges, these are:

- The complexity of the products: Each product has its own specifications in terms of engine, body, trim color etc.
- The complexity of the supply network: Supply network consists of different stocking locations and several hundred dealers
- Consumer behavior: New cars are made to order and customers compromise on specifications
- Demand seasonality: Varies between markets and affects the manufacturers.
- Ageing of stock: Unsold cars results in discounting to be sold (Turner & Williams 2005)

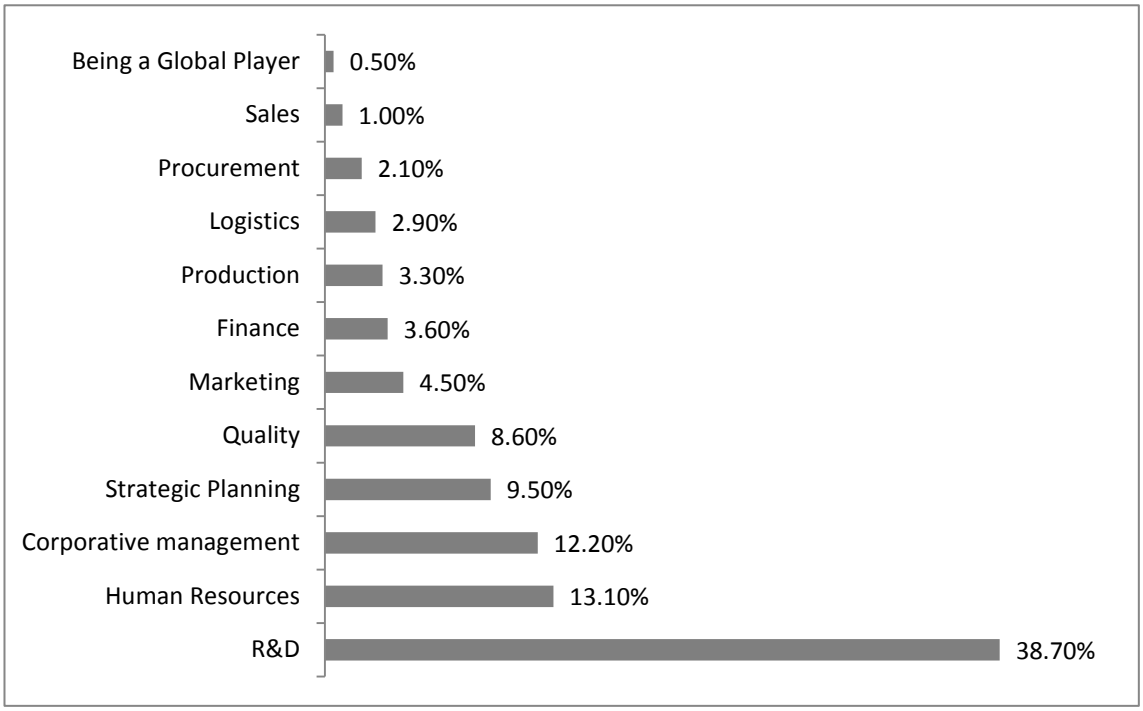
Lean manufacturing systems have influenced the relationship between supplier and OEM in the automotive industry. It requires closer relationship with sharing some functions, designing and producing components in close consultation. Delivery requirements have changed and relationships became long-term. (Dicken & Henderson 2003)

Relationship between suppliers and buyers in Turkish automotive industry is similar to the Western industry. It should be noted that, since the most Turkish automotive makers are joint ventures with foreign companies, their supplier management system is imported. Therefore, some trends have been adopted by Turkish automotive industry like strategic partnership, integration with larger suppliers and high level of outsourcing. (Kannan & Tan 2006) Moreover, Turkish automotive part suppliers also export their products; this means they are also important in global automotive sector (Karakadılar & Sezen 2012).

Key players in Turkish auto business are large firms; however, suppliers are mostly SMEs. Manufacturers seek system suppliers that can develop their own product design capability instead of individual part suppliers. Business partnership started to emerge in Turkish automotive industry; but buyer dominance is still a widespread against suppliers. Therefore, suppliers are financially and strategically more vulnerable. (Kozan et al. 2006; Kannan & Tan 2006) Furthermore, suppliers do not have the opportunity to produce or market their own technology; because, OEMs limit suppliers with tight specifications. (Wasti et al. 2006)

Turkish automotive industry is considerably powerful; however, there are things that must be improved by suppliers in order to compete in the developing global economy. (KPMG 2013)The area that must be improved is listed in the following figure.

Figure 13. Necessary improvements in Turkish automotive suppliers (KPMG 2013)



The relationship with suppliers in Turkish automotive industry can be improved by increasing the cooperation between parties in R&D areas and global projects. Transfer of human resources and developing logistics are also considered important for a better relationship. Therefore, success in the industry can come from collaboration. (KPMG 2013)

All in all, although there are some similarities in the supply chain of Turkish automotive industry with the Western industry, suppliers have less bargaining power in the market. OEMs are larger companies that have a systematic approach for supplying activities. There is large number of small sized suppliers in the industry; while few number of OEMs. Therefore, suppliers have so many competitors in the market and less power. Still suppliers must put effort to improve their relationship with customers in order to satisfy automotive OEMs in the market.

6. FINDINGS FROM TURKISH AUTOMOTIVE INDUSTRY

In order to understand supplier relationship and evaluate how important each of the supplier selection criteria for Turkish automotive industry, a question set was developed. Five interviews were arranged with the procurement managers of five different automotive companies in Turkey. The questions include; questions about supplier management, supplying activities and lean supplying; and a questionnaire to learn the important criteria for supplier selection. The questionnaire can be found in the appendix. The following section gives general information about the automotive manufacturers in this research.

Automotive OEM1
This company has been making buses in Germany since in the beginning of 1900s and the first plant in Turkey established in 1960s in Istanbul with a joint venture. Market share in Turkey is 56.8% and it is the leader company in Turkey for export of buses (about 2000 buses per year).

Automotive OEM2
This is a multinational automaker which headquarter is in USA. The plant in Turkey is a joint-stock company with a Turkish holding. It was established in 1970s. They produce about 300,000 vehicles per year which includes automobiles, light commercial vehicles and trucks. It is the automotive market leader in Turkey (23% market share) and also the export leader (3.5 billion $).

Automotive OEM3
This OEM is a multinational vehicle manufacturer, first established in France in 1900s. Turkish company is co-owned with the Turkish Armed Forces and established in 1960s. It only produces automobile in Turkey. It is an important brand in Turkey with approximately 15% market share in automobile industry. It is also an important player in automotive exportation (around 3.2 million $).

Automotive OEM4
This is also a joint venture company with the original Italian brand same shares with a Turkish holding. It produces automobiles and commercial vehicles. It was established in 1960s and its annual production capacity is 400,000 vehicles. It exports around 160,000 per year.

Automotive OEM5
Final OEM is a Turkish bus and midibus manufacturer. It was established in 1960s. They produce about 4,000 vehicles per year. The company exports 60% of its total production mainly to Western Europe and America.

6.1 Results

This section includes the research about the companies in order to introduce their values, supplying habits and requirements. First of all, when it is asked to procurement managers about their values, the favorite answers were:

1. Quality
2. Cost
3. Continuity
4. Timeliness

It can be said that quality, cost and delivery are also very important in the automotive industry as they are in other sectors. Quality is the main concern of automotive manufacturers while supplying systems and parts. Every company has its own standards for quality issues and suppliers must meet these standards. Quality must be also demonstrated by ISO certifications. Secondly, even though cost has lost its importance over years in procurement, it is still considered highly important mainly because of strong competition among firms. Thirdly, continuity refers to being continuous of quality, processes and relationship. Continuity provides long term cost efficiency to the companies. Finally, timeliness is also important for smooth processes inside plants.

When it comes to lean manufacturing, lean principles are important for automotive assemblers. They have some lean requirements from suppliers for a better production. Long term relationship with close collaboration is also considered important. However, they do not expect their suppliers to be completely lean. The next sections will give detail information about these subjects.

In the following section, the results from the automotive industry in Turkey will be discussed. Information about the companies by means of number of suppliers, relationships and preferred locations; and supplier selection and assessment of automotive manufacturers can be found in that part respectively.

6.1.1 Number of suppliers, relationships and locations

Number of suppliers of a company can show the relationship type preference of that company. Namely, reducing the number of suppliers is considered as developing closer

relationship. Therefore, companies can take the advantages of cost reduction, improved quality and fast production.

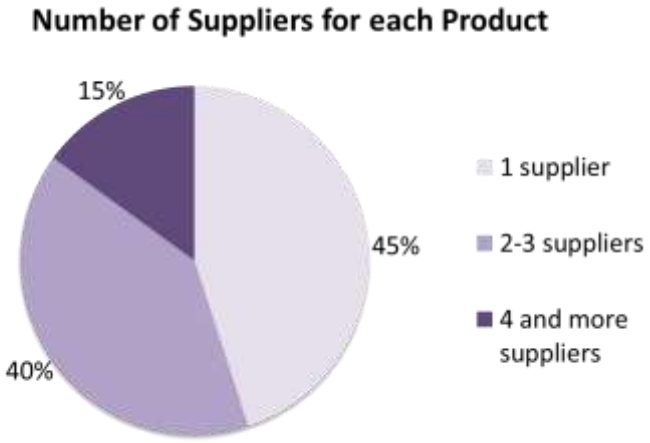


Figure 14. Number of suppliers for each product

As it can be seen from figure 14, Turkish automotive manufacturers usually prefer to maintain small number of suppliers. On the average, 65 percent of the products are purchased from only one supplier and only about 10% of the products are purchased from more than four suppliers. Even though, the manufacturers prefer to build close relationships with only one supplier; insufficient supplier knowledge on know-how and high number of ordinary products require contact with more than one supplier. It should be also bear in mind that automotive manufacturers have much more suppliers than average manufacturers which have a strong effect on this situation.

Beside the number of suppliers, level of cooperation between customer and supplier also shows the type of relationship. In this study, managers were described the relationship with their suppliers as close and cooperative. Even though most of them prefer to establish relationships at the same level with all suppliers, some suppliers have closer relationship with manufacturers. These suppliers are the ones have long-term relationship with manufacturers and/or the ones play supportive role in hard situations. The managers also point out that reliability and transparency are expected and required characteristics in their relationship.

When it comes to the location of the suppliers, local suppliers from closest locations are preferred mainly because of the cost of logistics. However, location is not the primacy for selection of suppliers.

6.1.2 Supplier selection and assessment

In the process of selecting a new supplier, every manufacturer has its own decision system. This system includes a road map and list of factors that have to be considered. The comprehensiveness of the system is different depend on the company and the

product that will be purchased. In the decision making process, not only the procurement departments play role; but also technical crew helps for the specifications. Especially for the international brands, the decision making process takes very long and slow mainly because of the level of hierarchy.

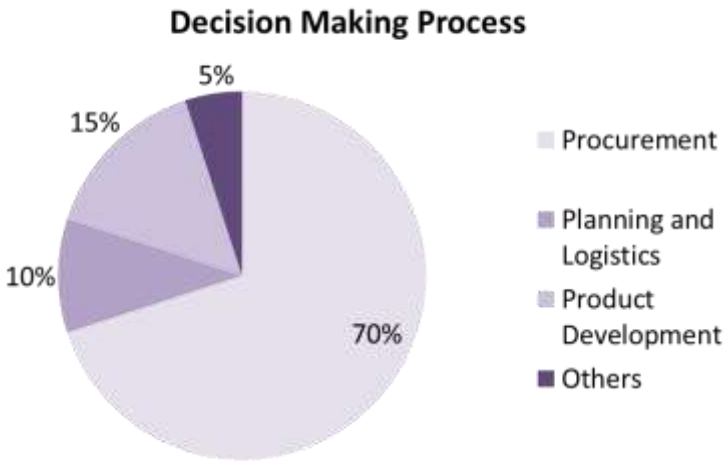


Figure 15. Roles on decision making process

The easiness to deal with a supplier is changed depend on the production type. For more ordinary products the process is shorter and easier. While the products get complicated the process is getting harder and longer. In some situations, it may take over two years to decide on a supplier. Several tests and analysis must be done to the product and the supplier before the final decision. Quality, design, R&D, investment and cost are the common specifications that are analyzed for this process.

The common challenges that automotive manufacturers in Turkey encounter in the decision process are:

- Not to find a qualified supplier for their specifications
- Long lasting price agreements with suppliers of specific products because of patent restrictions
- Logistics problems because of location of some suppliers

Although many assessments are done during the decision process, a supplier is assessed throughout the relationship. As in the decision process, every auto company has its own assessment system. This continuous assessment includes some standards that are defined by the company and each supplier has to pass from each standard in order to continuity of the relationship. Also, some companies have supplier technical assistance (STA) who is responsible from each supplier. Therefore, suppliers can be controlled frequently.

6.1.3 Lean supplying

Turkish automotive companies apply lean techniques in their production system in order for efficient and quality production. They also have some requirements from suppliers which are also considered as lean characteristics. Suppliers fulfill the requirements of the auto manufacturers instead of becoming completely lean. Therefore, most of the suppliers are not considered as lean and they are just trying to protect their relationship with their customers.

It can be said that in Turkey automotive OEMs are lean mostly in production and in management system; however, most of the automotive suppliers are behind to adopt these techniques in their production. OEMs are trying to improve their suppliers in many areas; however, developing lean principles is not their main concern. The reasons of this situation can be listed as:

- Large number of supplied parts
- Large number of ordinary and small parts
- Difficulty and complexity of controlling large number of suppliers
- Lack of qualified supplier in the market

According to managers of procurement teams, JIT is the most important principle for supplying. The required parts have to be available when they are needed. However, they do not avoid to store more than the need in order to avoid out of stock. Therefore, in today's situation Automotive OEMs in Turkey have more than enough space for inventory storage.

Some parts which are specific to a single auto can be ordered and delivered for each product such as air conditioner. These products usually occupy large spaces than others and mass transportation can create additional problems. However, most of the automotive parts are not considered in this situation.

6.2 Criteria for supplier selection

The respondents were requested to rank list of criteria for supplier selection on the scale of zero to five (0-5). Scale of 5 is given for the extremely important criteria and 0 is given for the least important ones. The full set of the questionnaire can be found in the appendix. In order to understand the average importance of each criterion in the industry, mean value of the rankings were calculated. The tables in the next parts include criteria and mean value of the rakings given by the manufacturers.

The criteria list consists of seven major parts which are (1) quality and cost, (2) delivery, (3) services, (4) supplier relationship, (5) management and organization, (6) capabilities and (7) lean principles. Each part has its own specific criteria that are ranked. In the following part the results for each category will be discussed. Each category contains a related criteria table which demonstrates mean values of each

criterion. Therefore tables from 13 to 19 includes list of criteria that was asked to manufacturers and mean values of their responses.

6.2.1 Quality and cost

Quality and cost are considered as the most important criteria with delivery in the literature. According to the responds of the automotive OEMs, Table 13 indicates that ISO certification is highly crucial. Every manufacturer ranked this criterion with the highest grade. Having ISO certificate is must for suppliers in order to deal with the automotive manufacturers in Turkey. ISO 16949 is the most important according to the manufacturers. ISO 16949 is a quality management system in automotive industry and defines the requests of automotive manufacturers. It aims continual improvement, defect prevention and reduction of waste in the supply chain. (Anon 2014)

Table 13. Ranking of quality and cost criteria

Quality and cost	**Mean**
Meeting minimum standard	4.8
Long durability	4.4
ISO certification	5
Low return rate	4.2
Provide sample before first order	4.6
Technical expertise	4
Low price	4.4

After ISO certification, meeting minimum standard is the second important criterion in this class. Every manufacturer has its own standards that were determined beforehand for each product and a supplier and its products must fit all the standards. Therefore, this is also one of the very crucial items for manufacturers.

Providing sampler before first order, long durability and cost are the following important criteria. Since the lowest rank given among all criteria is 4 (Technical expertise), it can be said that quality and cost are very important for supplier selection.

6.2.2 Delivery

Delivery is another crucial factor that manufacturers take into consideration while selecting suppliers. In table 14, delivery results from the questionnaire can be seen; according to it, delivery is very important also for automotive manufacturers. While short lead time is highly preferred from suppliers, there is no tolerance for error in production type or quality. Since all the parts received by auto plants have a specific

usage in an auto, any mistake in the product type or quality causes production lag. For automotive manufacturing it is quite undesired situation which results in high costs.

Table 14. Rankings of Delivery

Delivery	Mean
Short lead time	4
Reliable method of delivery	4.6
Good packaging	4.2
Receiving in good condition	4.6
No error in product type or quantity	5

Second important criteria are reliable method of delivery and receiving products in good condition with 4.6 mean values. The overall result of delivery shows that delivery is as important as quality.

6.2.3 Services

Services include help and support of the supplier in some occasions like technical service and after sales service. Table 15, shows the mean values of this category according to rankings of automotive OEMs. Warranty/insurance of parts and fast response from supplier are slightly more important than after sales service and technical support. The main reason of this situation is that auto manufacturers usually have better knowledge on technical parts than suppliers. Therefore, they do not always need support after the sales. However, they require having the warranty of the parts they purchased and accessing suppliers in the case of a problem.

Table 15. Rankings of services provided by supplier

Services	Mean
After sale service	3.8
Technical support	3.8
Warranty/insurance	4.4
Fast responsiveness	4.4

6.2.4 Supplier relationship

Type of relationships was discussed in chapter 2 and it was mentioned that there are various type of relationships. Relationship types show the cooperation and closeness between supplier and customer. While lean requires close and long-term relationship, traditional approaches are totally different. Therefore, criteria selection under this category can show the level of leanness of Turkish automotive industry.

The sub-categories can be seen in table 16 with their mean values obtained from the selections of automotive manufacturers. According to this table, good relationship management and long-term cooperation are very important. Good and long-term relationships reduce the total cost and effort spends by auto-manufacturers in the long-run. Responsibility and honest & frequent communication are the following important criteria selected by auto-manufacturers.

Performance history, supplier's willingness to share confidential information and communication system of supplier are considerably important for automotive OEMs. Finally, cultural match has very little importance among other criteria.

Table 16. Rankings of supplier relationship

Supplier relationship	**Mean**
Good relationship management	4.6
Performance history	3.6
Responsibility	4.4
Long-term cooperation	4.6
Current customers	2.8
Cultural match between companies	2.2
Communication system	3.4
Honest and frequent communication	4.4
Supplier's willingness to share confidential information	3.6

6.2.5 Management and organization

Organization and management includes the aspects that are directly related with the supplier companies but not with their products. Characteristics of the company and its management system are considered under this section. For this part, the procurement managers were asked to rank 12 sub-criteria. The list of the criteria can be seen in table 17.

Table 17. Rankings of management and organization of supplier

Management and organization	**Mean**
Organization structure	2.4
Staff skill and potential	3.6
Labor relation	2.2
Reputation	3.6
Company background	3.2
Amount of past business	3.4
Location	3.2
Financial status	3.6
Company size	2.4
Supplier's believability and honesty	4.6
Positive attitude towards complaints	4.4
Environmental awareness of supplier	4.2

Mean grades of the rankings show that characteristics of management and organization are not as important as quality, cost and delivery criteria. The most important criteria under this section are supplier's believability and honesty, positive attitude towards complaints and environmental awareness of supplier respectively.

On the other hand, organizational structure, labor relation and company size have very little influence on supplier selection in automotive industry.

6.2.6 Capabilities

Capability criteria show the ability of suppliers in the areas like technological and developmental. Five sub-criteria were analyzed for this section. The results demonstrate that capabilities are also one of the important requirements of auto manufacturers from suppliers.

Technical know-how is the most important capability that is required from suppliers with 4.4 mean value. It is followed by R&D capabilities, flexibility and ability to handle exceptions and problems. As a result, technical knowledge and ability is important for auto OEMs especially for their continuous improvement.

Table 18. Rankings of capabilities

Capabilities	Mean
Ability to handle exceptions and problems	4
R&D capabilities	4.2
Technical know-how	4.4
Existence of IT standards	3.2
Flexibility	4.2

6.3 Effect of lean manufacturing on supplier selection criteria

Even though lean philosophy is obviously seen only in OEMs of Turkish automotive industry, suppliers are obligated to apply some principles of lean. Suppliers are not becoming lean with their own initiation; however, requirements of the customers make them leaner. Therefore suppliers must follow some lean techniques in order to stay in the market.

While selecting suppliers, manufacturers consider so many criteria which include product, service and company specifications. When it is looked their important criteria for selection, some principles of lean can be seen. In this study, the lean principles that are considered by Turkish automotive OEMs while selecting their suppliers are found as:

- Supplier integration
- Waste elimination
- JIT
- Continuous improvement

First of all, supplier integration is seen in the requirements of OEMs when selecting their suppliers. When it is asked their supplier preference, they prefer to have less (only one if it is possible) supplier with a long-term cooperation. They also prefer to have a close relationship with their suppliers with collaboration. Therefore, they aim to achieve long-term cost and quality benefits.

Table 19. Rankings of the lean principles

Main lean principles	**Mean**
Effort in elimination of waste	3.4
Effort in promoting JIT principles	4.6
Commitment to continuous improvement in products and processes	3.8

Secondly, elimination of waste is another criterion that can be considered as important. The mean of the rankings given for this criterion is 3.4. Some wastes that are crucial for OEMs are:

- Wrong product
- Error in the quantity of ordered material
- Failure in the quality of the product
- Defects in the products

OEMs have no tolerance for wrong product type or quantity deliveries. Any product that has not arrived with a right quantity affects the production process and cause cost and time. Since efficiency is highly important for lean manufacturing, suppliers also eliminate any failure and defects in the products. Quality criterion was ranked as very important; therefore, any product that does not meet the minimum quality requirement is considered as waste and must be eliminated.

Thirdly, JIT principle of lean is also one of the important criteria in supplier selection. Managers ranked this criterion as very crucial and the mean value is 4.6. This can be seen in table 19. Even though OEM's only interested in delivery part of JIT principles, they know that it is only achieved by JIT production. Therefore, suppliers must produce and deliver the right parts at the right quantity and right time.

Finally, continuous improvement is an also a parameter to be selected as a supplier. Suppliers must certificate their performance by ISO 16949. This certificate is the principle requirement of many automotive OEMs in Turkey. Mean value of continuous improvement in the questionnaire was 3.8.

All in all, automotive suppliers in Turkey are improved themselves by the requirements of OEMs. Principles of lean manufacturing are applied in production of every automotive OEM and in order to completely apply these principles suppliers must also spend effort on it. Therefore, OEMs put some criteria while selecting their suppliers.

Suppliers are comparatively lean with the principles they have to do in order to keep their places in the market. However, this is not achieved by their initiation. As it was mentioned in the previous chapter, customers have high bargaining power on suppliers in the automotive industry. This situation can be seen in lean activities of suppliers, just because customers force it on to suppliers.

7. DISCUSSIONS

7.1 Conclusion

There have been many researches about relationship between customer and supplier in B2B market and they show that many changes have occurred in the type of relationships over years. While traditional relationship focuses on short-term benefits for both parties, now relationships are more collaborative, long-term and close. Because, in today's world markets are so challenging and establishing this kind of relationships provide many benefits in the long run. Companies develop strategies for long-term effective relationships, so improve their performance.

The most important part of establishing long-term collaborative relationship with suppliers is selecting them in a proper way. Therefore, companies build their own method for supplier selection process. These methods include some steps that are determined according to company strategy. The general steps that are followed while selecting suppliers are (1) recognizing the need for a supplier, (2) determining procurement strategy, (3) identifying criteria for suppliers, (4) assigning weights to each criterion, (5) defining technique, (6) pre-qualification, (7) evaluating potential suppliers, (8) final selection and (9) monitoring. Even though, the supplier selection method provide a roadmap for selection, supplier selection process is challenging because of finding the optimum supplier with using more than one criterion and hierarchy of decision making in companies. Therefore, choosing proper criteria is also very crucial before the selection process.

The first research about supplier selection criteria was done by Dickson in 1966 with his study of "An analysis of vendor selection systems and decisions". He conducted a survey with purchasing agents and managers and found out 23 criteria. After that, Weber et al. followed the study of Dickson in 1991. He researched 74 articles and categorized the list of Dickson's 23 criteria.

The past studies about criteria selection show that most popular criteria were price, quality and delivery. Over years, while the importance of price decreasing, quality become the most crucial item for selection of suppliers. Moreover, new criteria have emerged and become popular over years like technical know-how, research & development and flexibility. There is no optimum criteria list that can be used by every company. On the contrary, each company must build its own list of criteria for supplier selection; because supplier selection criteria are highly dependent to country, industry, position in the supply chain, type of products, type of sourcing and required collaboration.

The supplier selection processes and criteria are continuously evolving and improving over years. The most common reasons of this situation are globalization, the need for collaborative relationships and increase in environmental awareness. Moreover, companies recognize the importance of lean manufacturing techniques and they gradually looking for suppliers which follows lean techniques in the production. Therefore, it can be said that lean concept is entering procurement activities and a new term ‘lean supply’ is started to be used.

Lean production concept first emerged from Toyota production system. It aims to improve efficiency by cost reduction, higher productivity and higher quality. The main principle of lean production is waste reduction. Any kind of non-value activities must be eliminated for efficient production. Waste reduction includes wastes in overproduction, defective parts, inventory, inappropriate processing, transportation, waiting and unnecessary motion. Other popular principles of lean are continuous improvement, JIT production & delivery, pull instead of push, multifunctional teams with integrated functions and supplier integration.

However, lean production is not limited with the production process of the company. Instead, in order to be lean, all the activities around the company must be lean including procurement activities. Therefore lean companies must supply with following lean principles. These principles can be analyzed in three category, these are supplier relationship, supplier’s production and supplier’s logistic performance. By means of relationship, lean requires collaborative and integrated relationship in which there is an improved flow of information between parties. Production system of supplier must also support lean especially with JIT and pull principles. Some kind of production process can be done together with the customer. Therefore, product quality and supplier flexibility can be improved. Moreover, logistic performance of suppliers improves with lean techniques with improvements in transportation and on time delivery. All in all, lean philosophy diffuses to supply chain by offering developments in many areas and lean companies consider lean criteria while selecting their suppliers.

In this thesis, automotive industry in Turkey is selected as the study subject for diffusion of lean to supply channels and supplier selection criteria evolution with lean philosophy. It was selected because automotive industry is the first industry that lean production emerges and it has a very complex supply channel.

An automotive supply chain can be divided into three parts. These are; first-tier suppliers which provide complex systems, second-tier suppliers that supply modules and component parts and third-tier suppliers which are responsible from supplying raw materials and generic engineering parts. Supplying in the automotive industry is challenging; because of complexity of products, complexity of supply network, consumer behavior, demand seasonality and aging of stock.

Turkish automotive industry is the third largest industry in Turkey with 22 brands; however, most of them are joint ventures with foreign companies. Therefore, there are many similarities with western automotive companies in Turkey. While the

OEMs of automotive companies are very large, suppliers consist of small and medium size companies.

A study was conducted in Turkish automotive industry to understand the criteria selection and lean diffusion into supplier selection process. Interviews were arranged with procurement managers of five automotive companies in Turkey. According to the results, the values of procurement activities are quality, cost, continuity and timeliness. Automotive OEMs prefer to have less number of suppliers with close collaboration and long-term relationship. They have a detailed decision making system for selecting suppliers and selected suppliers are evaluated by systematic assessment throughout the relationship. Decision making process is long and hard; and more than one department play role on decision making.

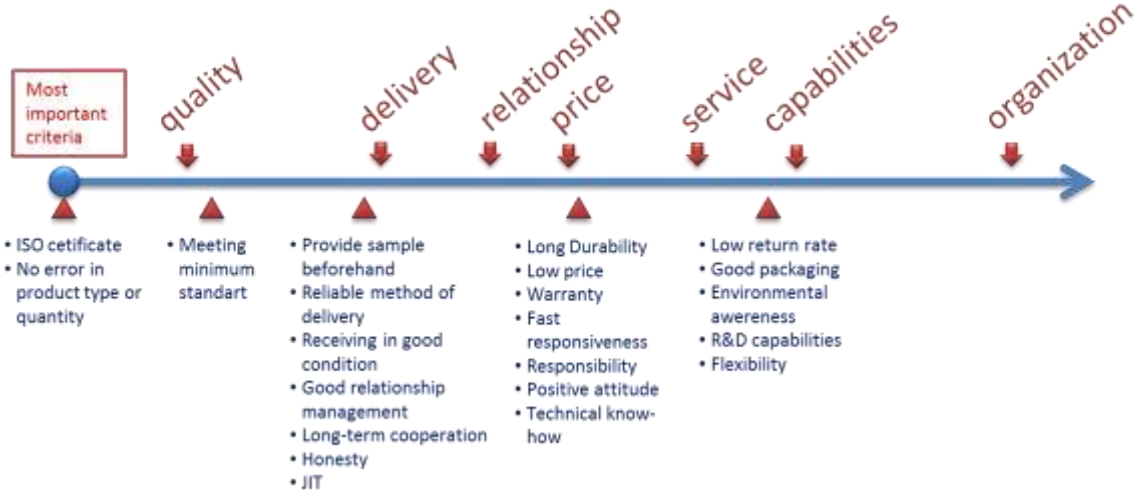


Figure 16. The most important criteria for Turkish automotive industry

When the results of the criteria questionnaire are analyzed, it is shown that quality is the most important parameter while selecting suppliers. ISO certification is must for every supplier to be selected and suppliers must prove their products to meet the minimum standards of clients. After quality, delivery is the second important criteria for automotive OEMs. Manufacturers have no tolerance for error in product type or quantity. Also, JIT delivery with reliable method and receiving in good condition are also crucial.

Price comes as the fourth important criteria after relationship management. Namely, long-term cooperation, honesty and good relationship management are more important for supplier selection. While service and capabilities are slightly important, few items are considered important from organizational criteria. For service, warranty and fast responsiveness are important; and for capabilities technical know-how is selected as important criterion.

In Turkey automotive industry is the most active industry in lean production activities. All the automotive companies in this research apply lean principles in their

production. They also have some requirements from their suppliers that lean philosophy offers. Therefore, the effects of lean philosophy can be seen in the criteria selection of procurement managers. The most important lean principles that automotive manufacturers in Turkey require from their suppliers are:

1) JIT
2) Waste Reduction
3) Continuous Improvement

First of all, JIT is one of the most important requirements of supplier selection. Products must be arrived at the right quantity and right time. Secondly, waste must be eliminated in terms of wrong products, error in the quantity and quality of the products and defective products. Thirdly, continuous improvement must be proved by ISO certifications; which makes it very crucial for supplier selection.

The objective of the procurement teams of automotive OEMs in Turkey is establishing close, collaborative and long-term relationships with their suppliers as lean manufacturing requires. Hence, supplier integration is an important criterion that they put effort on it.

However, from the point of lean supply, automotive suppliers in Turkey cannot be considered as completely lean. Customer requirements make suppliers to apply some lean principles in production and delivery. It can be said that OEM's activities and efforts in lean manufacturing are not reflected to the supply chains of automotive industry. OEMs put efforts on suppliers in order to improve them and achieve better standards. However, there are some common reasons that prevent them. These are generally:

- Having complex supply chain
- Difficulty of controlling large number of suppliers
- Large number of ordinary parts to supply
- Lack of qualified supplier in the market

On the other hand, Turkey has an unstable position in business and economics; and the industries are influenced negatively from this condition. Especially, automotive suppliers which are small and medium sized businesses can be highly affected any economic downturn. Therefore, large investments on suppliers are too risky for Turkish automotive OEMs.

To sum up, the mentioned reasons prevent suppliers of the automotive OEMs to adopt lean manufacturing techniques completely. In order to have lean supply chains in Turkish automotive industry;

- Stability must be seen in Turkish economy
- Suppliers must be qualified and have technical know-how
- Relationship with suppliers must be improved

Therefore, OEMs of Turkish automotive industry can compete in the global market with more power by means of stable and completely lean supply chain.

7.2 Limitations

Even though the scope of this research focuses only on Turkish automotive OEMs, there are some limitations in this study. This means that this study can be achieved with better results without several limitations.

There are 22 automotive OEMS in Turkey, but this research includes only 5 of them; because of unwillingness of other companies to attend this kind of research. Although 5 manufacturers are the most known largest brands, a study with the all 22 brands gives better and more accurate result for this study.

Moreover, some interviewers are very eager to share their information and they even explain more than asked to the questions. However, some of them are unwilling to share all the required information, because they think information for this research is confidential.

Some procurement managers have limited knowledge about lean and lean practices; which influences the efficiency of this study. These firms mostly apply lean principles in production process; however, people from procurement departments only know their parameters for supplier selection independent from lean. Nonetheless, this situation helps to demonstrate the level of lean in supplying activities.

Finally, during the literature review so many related documents were reviewed; however, there are much more books and articles that could not be accessed and could not be added to this research. Namely, this research was done with the available resources and with additional resources more detailed research can be done.

7.3 Future research possibilities

There is some further research possibilities that could be done related with this subject. For example, this research could be repeated with investigating all 22 automotive OEMs in Turkey. This research generalizes the results by using the answers of 5 manufacturers. If all the manufacturers attend to the research, the result might be slightly different. Moreover, more than one member from each company could be interviewed and the optimum result from each manufacturer can be achieved. The number of questions related with lean philosophy could be increased and more detailed result could be obtained with more interviewers.

Additionally, this research only includes automotive OEMs and the situation from their perspective. Since this subject also concerns suppliers, a similar research can be done with first-tier suppliers. Therefore, their relationship expectations, opinions for lean production and efforts for meeting the criteria requirements could be understood better. However, it should be bear in mind that such study requires to survey much more than 5 companies for an accurate result.

Finally, since lean manufacturing techniques are continuously evolving and number of adopters, especially suppliers, are increasing; an analysis about the future of supply chain and supplier management in Turkish automotive industry could be done. Some models from European countries and USA could be used for this kind of research. Therefore, an idea for the future of the automotive supplying could be produced and it could be used for future developments.

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APPENDIX

INTERVIEW QUESTIONS

(Questions to understand the firm, its suppliers and supplier decision process)

1) What are your core values for supplying activities?
2) How many suppliers do you have for each product?
3) How do you describe your relationship with current suppliers? Are level of cooperation and closeness same for every supplier?
4) How often do you assess current suppliers?
5) What is your preference location of suppliers?
6) Who plays role on decision making process of suppliers?
7) How easily do you decide on to work with a supplier?
8) What are the challenges for selecting suppliers to work with?

(Questions related to lean practices)

1) Which practices of lean do you apply currently? In what level do you apply lean practices? (In production, procurement, management etc.)
2) Do you prefer to improve current suppliers or switch suppliers for improvements? (Lean supplying etc.)
3) What is your requirement level of lean in supplying?
4) What is the level of leanness your current suppliers by means of supplying components?
5) How long have you considered lean supplying as important?
6) What are the important parameters for you for lean supplying?

QUESTIONNAIRE OF CRITERIA RATING

(In this part, firm rates each supplier selection criteria. Rating score is from 0 to 5. 0 means not important at all, 5 means extremely important.)

Quality	**Rating (0-5)**
Meeting minimum standard	
Long durability	
ISO certified	
Low return rate	
Provide sample before first order	
Technical expertise	
Delivery	
Short lead time	
Reliable method of delivery	
Good packaging	
Receiving in good condition	
No error in production type or quantity	
Services	
After sale service	
Technical support	
Warranty/insurance	
Fast responsiveness	
Supplier relationship	
Good relationship management	
Performance history	
Responsibility	
Long-term cooperation	
Current customers	
Cultural match between companies	
Communication system	
Honest and frequent communication	
Supplier's willingness to share confidential information	
Management and organization	
Organization structure	
Staff skill and potential	
Labor relation	
Reputation	
Company background	
Amount of past business	
Location	
Financial status	

Company size	
Supplier's believability and honesty	
Positive attitude towards complaints	
Environmental awareness of supplier	
Capabilities	
Ability to handle exceptions and problems	
R&D capabilities	
Technical know-how	
Existence of IT standards	
Flexibility	
Main lean principles	
Effort in elimination of waste	
Effort in promoting JIT principles	
Commitment to continuous improvement in products and processes	